

Materials

JULY 1961

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Research & Standards



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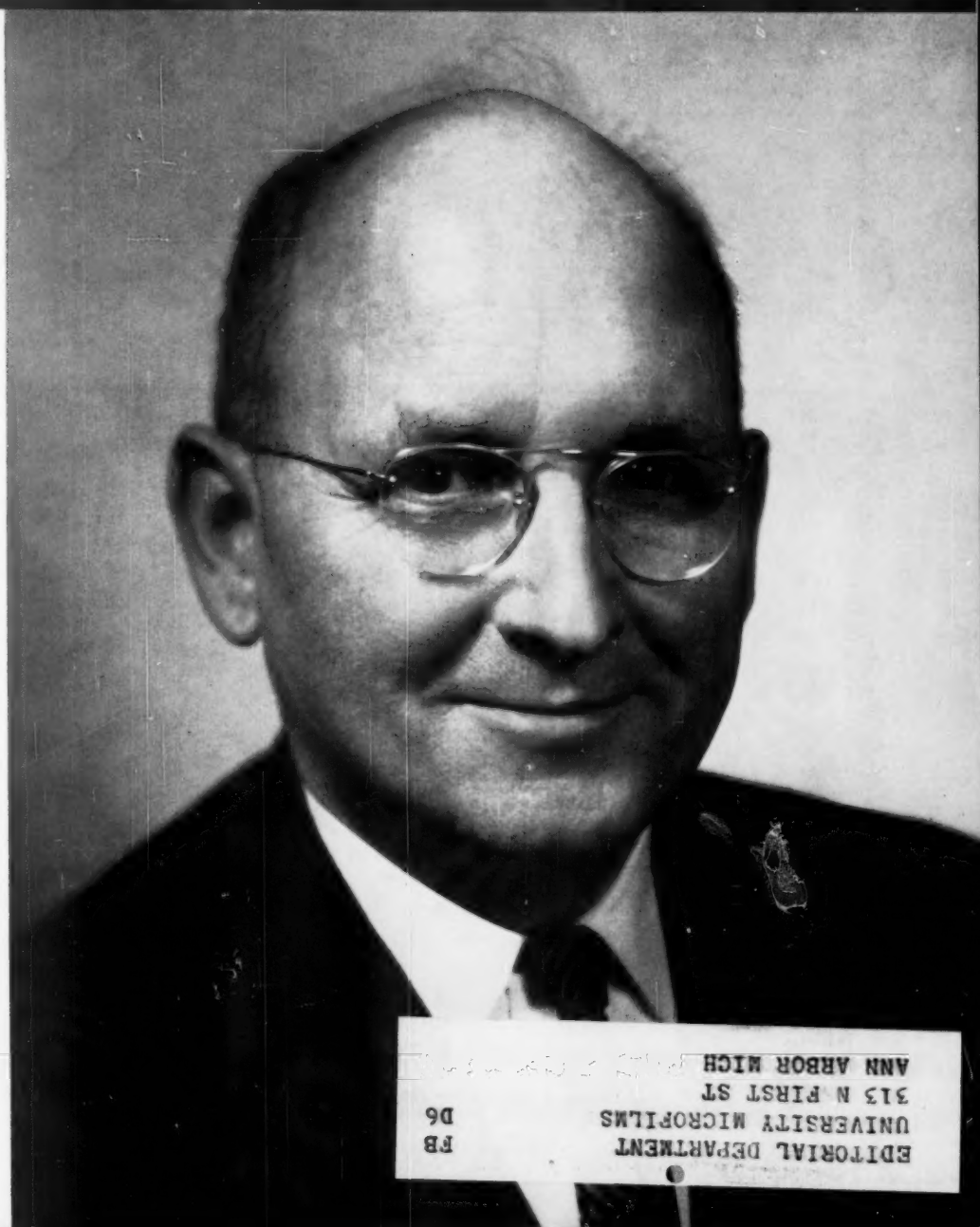
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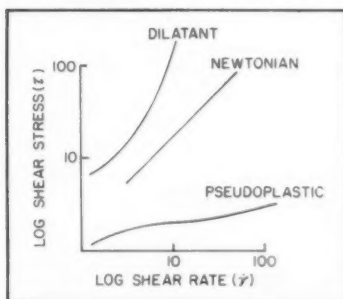
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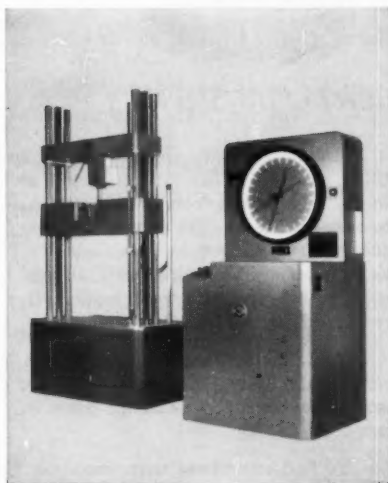
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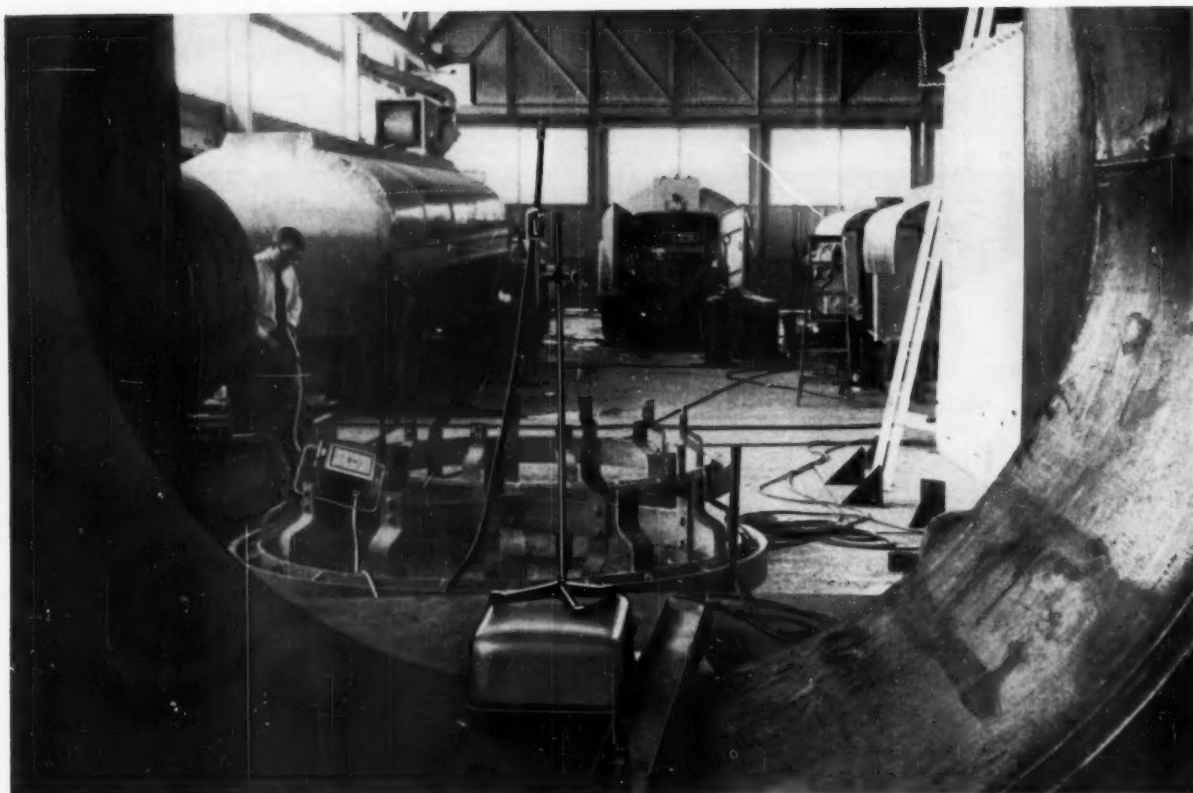
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In This Issue...

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COVER PHOTO:

Miles N. Clair, 55th president of ASTM (see page 561).





Nike-Zeus Missile roars aloft from White Sands Missile Range

IMPACT!

New Plas-Tech Full-Range Universal Tester helps Grand Central Rocket Conquer Rocket Grain Integrity Problems

THE PROBLEM — The research team at Grand Central Rocket Company was challenged by the need for design criteria for both large and small solid propellant rocket motor grains. A fundamental requirement in developing these criteria was physical characterization of the viscoelastic propellants in tests simulating the storage, transportation, ignition and launch forces imposed on rocket grains.

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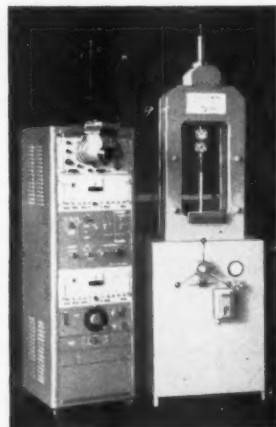
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Pros and Amateurs

THE OLD SAW about the specialist knowing more and more about less and less until he knows everything about nothing may be reversed with the materials scientist, who may find himself in danger of knowing nothing about everything. To those who say that there is too much specialization, it can also be said with some justification that there is not enough.

We can expect more rather than less emphasis on the interdisciplinary aspects of materials. This fact has always been known to us in ASTM, since we are oriented horizontally in the field of materials, which embraces all the physical sciences. But while we know that all the sciences must be brought to bear on materials problems, most of us are "pros" in only one of the physical sciences or branches of engineering. So where does that leave us?

Let's take an example: Jones is a chemist, a Ph.D. who did his graduate work in high polymers—polymerization kinetics, molecular weight measurements, etc. Jones is now a plastics expert, and expert he is in polymer chemistry, because he has had rigorous training, and produced original research here. But his job now calls for him to be an expert in electrical and mechanical aspects of plastics as well. Here his approach must be interdisciplinary. What does he do? Go back to graduate school and get additional degrees in applied mechanics and electronics? Not likely. He bones up—uses the library, adds books to his private collection, and otherwise becomes acquainted with these new fields. Is he now a pro in all these fields? He may be, but more than likely he is only a capable amateur in fields other than his specialty.

The team approach is coming to be the rule in research on materials where a number of specialists work together. This would appear to be a preferred alternative to each of us attempting to become a "jack of all trades."

This is not to say that knowledge of more than one field is undesirable; rather, we should recognize our limitations, and though we have become conversant with new fields, we should not hesitate to consult the expert on matters on which we are not pros.

F. Y. S.

Laboratory Preparation of High-Purity Tricalcium Silicate

By M. POLIVKA, A. KLEIN, and C. H. BEST

THE SYNTHESIS OF tricalcium silicate of high purity in 10 lb quantities was attempted for use in studies of the effect of temperature on the creep characteristics of the hydrates.¹ The immediate objective was to produce the compound with a minimum of burning at 1650 C and with good grindability so that contamination by attrition of grinding media during grinding would be minimized. The procedure is reported for the benefit of those investigators concerned with portland-cement research who may wish to produce tricalcium silicate in quantity for their own use. Procedures for beta-dicalcium silicate, tricalcium aluminate, and tetracalcium aluminoferrite will be investigated in that order, and significant results will be reported as they become available.

Techniques of Other Investigators

Perhaps the most descriptive work on the manufacture of tricalcium silicate was reported by Lerch and Bogue (1),² who adopted a special procedure because the highest temperature available to them was 1500 C, a temperature too low for complete combination of lime and silica if all necessary calcium carbonate is added to the raw mix prior to the first burn. The raw mix contained calcium carbonate and silica sufficient to yield a lime-silica molar ratio of about 2.3. Additional calcium carbonate was interground with the clinker to bring the ratio to 2.9 in stepwise fashion. At this stage they established, by chemical analysis of the clinker, the amount of calcium carbonate necessary to increase the molar ratio to 3.0. Each mixture was heated to 1500 C and held at that temperature for 3 hr. A minimum of four such burns was necessary with grinding after each firing. The microscope

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¹ These studies were sponsored by the National Science Foundation Grant No. G6562; Milos Polivka and John E. Dorn, faculty investigators.

² The boldface numbers in parentheses refer to the list of references appended to this paper.

A simplified procedure for the preparation of tricalcium silicate with a purity higher than 99 per cent from reagent grade calcium carbonate and either high-purity flint or silicic acid is described. Only one relatively low-temperature burn (1450 C) and one high-temperature burn (1650 C) without intermediate grinding are required, rather than the multiple high-temperature burns with grinding between all successive burns reported by other investigators. Included are details of furnace and hearth selection, raw mix preparation, and firing and quenching techniques. The results of chemical analysis, of differential thermal analysis, and of X-ray comparison with a sample of tricalcium silicate supplied by the Portland Cement Assn. are reported. It is shown that the grindability of the product depends on the nature of the raw materials employed; clinker made with flint as a source of silica is much harder to grind than that made with silicic acid.

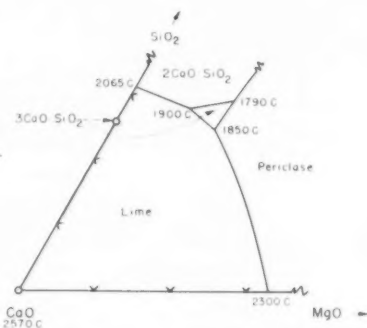


Fig. 1.—Portion of the system CaO-MgO-SiO₂ (from Ricker and Osborn (6)).

showed the product to be practically pure tricalcium silicate with a trace of beta-dicalcium silicate and no free lime.

Bogue (2) has reviewed in considerable detail the work of Bates and Klein (3), Hansen (4), and Weyer (5), all of whom reported the use of multiple burns to produce a reasonably pure product. The authors also had the benefit of the cooperation of L. E. Copeland, senior research chemist, Portland Cement Assn., who made several extremely valuable recommendations.

Simplified Procedure

Briefly, the procedure adopted was to

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CECIL H. BEST has been active in cement and concrete research for the past seven years, first at the University of California, Berkeley, where he received his Ph.D. in engineering science, 1960. Currently he is engaged in research at the Technical University of Norway, Trondheim, under a post-doctoral fellowship of the Royal Norwegian Council for Scientific and Industrial Research.

burn calcium carbonate and either flint or silicic acid at 1450 C, cool in the furnace, slake with water, burn again at 1650 C, cool in the furnace to 1450 C, and quench in an air blast. The cooling from 1650 to 1450 C in the furnace before air quench was done only to protect the furnace lining from excessive thermal shock.

Selection of Furnace

A global-electric furnace was used for the initial firing of the raw mix at 1450 C. An alumina-lined gas-fired furnace proved satisfactory for the second firing, because a temperature of 1650 C could be achieved readily using high-pressure gas, and because the capacity was sufficient to yield several pounds of compound per firing. Practical considerations of hearth weight and ease of handling resulted in charges to produce 2 to 3 lb of product.

Selection of Hearth

A study of the phase diagram for the system CaO-MgO-SiO₂ (Fig. 1) indicates no probable reaction between the CaO-SiO₂ charge and the MgO hearth below 1790 C. Periclase bricks were sawed into hearth plates and soaked for 24 hr at 1650 C to remove volatiles before they were put into service. Each plate could be used three or four times before cracking severely.

Periclase stabilized with chromic oxide was also investigated, but in the presence of tricalcium silicate it proved to be less resistant to thermal shock than the unstabilized material.

Preparation of Raw Mix

Reagent-grade precipitated calcium carbonate, preferably low in alkalis, and ground high-purity flint were mixed with water to produce a thick slurry. The proportions of reagents gave a CaO-SiO₂ molar ratio of 3.0. The slurry was spread on a polyethylene sheet in an even thickness of about $\frac{1}{4}$ in. and allowed to dry. When the slurry showed some cohesiveness, it was cut into pieces about 1 by 2 in. When dry enough to be handled without breaking, the pieces were stacked on a hearth plate. The charge was then dried at 110 C prior to firing.

Firing and Quenching Technique

The hearth plate with the charge of dry raw mix was placed in the global electric furnace, fired to 1450 C, and held at that temperature for about 3 hr. This initial firing caused a partial reaction between lime and silica, and at the same time insured the presence of a substantial amount of free calcium oxide. When the charge had cooled, a sample was taken for chemical analysis. The lime-silica ratio was adjusted, if necessary, by adding an appropriate amount of calcium carbonate or of flint to the burned material. The

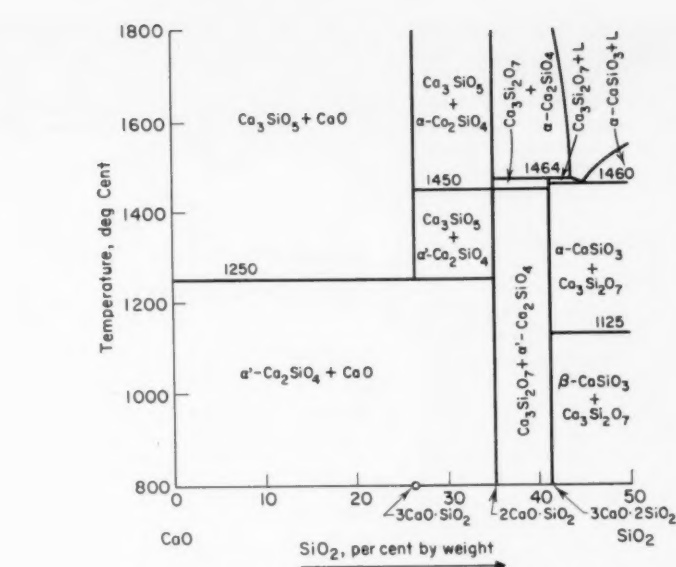


Fig. 2.—Portion of the system CaO-SiO₂ (from Glasser and Osborn (7)).

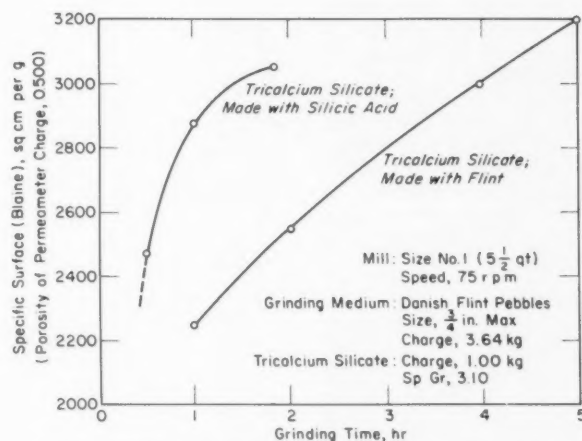


Fig. 3.—Grindability of tricalcium silicate clinkers made with flint and with silicic acid.

burned material and the corrective material were then mixed with water. The slaking of the free lime present was sufficiently disruptive to destroy the structure of the clinker completely. Hence, grinding at this stage was avoided.

This slurry was processed in the same manner as that for the first burn, in preparation for the high-temperature burn which followed.

The clinker from the layer adjacent to the hearth plate was kept separate and was used in the same position in each subsequent firing. There was some contamination of this layer by volatiles not completely removed by the heat-soaking of the periclase. Spectrographic examination showed the contaminant to be principally an oxide of chromium in amounts of 0.01 to 0.02 per cent by weight.

After 24 hr in a drying oven, the charge for the high-temperature burn was placed in the furnace. At this stage, the material consisted of some hydrated calcium silicate and, for the most part, of calcium hydroxide and silica. The furnace charge was brought up in about 6 hr to a temperature of 1650 C., where it was held for 3 hr. At the end of this hold time the gas was shut off and the furnace was allowed to cool to 1450 C. The charge was then removed and quenched in an air blast provided by a large fan. The furnace was closed immediately to protect its liner. As soon as all red glow disappeared from the clinker, it was stored in a desiccator to protect it from atmospheric moisture and carbon dioxide. The temperature of 1450 C was chosen as that from which to quench, because tricalcium silicate is

unstable below 1250 C and can dissociate into beta-dicalcium silicate and free lime if allowed to cool slowly (Fig. 2); 1450 C is low enough so that the opening of the furnace door is not too severe a shock to the furnace lining, yet the margin of 200 C is sufficient to allow transfer of the charge from the furnace to the quenching area before dissociation can begin.

Grindability Studies

The possibility of improving grindability of the clinker in order to reduce contamination during grinding was investigated briefly. At the suggestion of L. E. Copeland, silicic acid was used in place of flint as a source of silica in making a batch of tricalcium silicate for comparative grinding studies. A 1-kg sample of each product was ground at 75 rpm in a No. 1 (5½ qt) pebble mill charged with 3.64 kg of Danish flint pebbles having a maximum size of ¾ in. Figure 3 shows specific surface³ plotted as a function of grinding time. Silicic acid in place of flint as a source of silica greatly reduces the grinding time required to produce a given fineness, at least up to a specific surface of about 3000 sq cm per g.

Table I shows X-ray spacings for tricalcium silicate made with flint (column 3) and with silicic acid (column 5); no significant differences between the two products were seen.

As a result of these tests, silicic acid was subsequently used exclusively as the source of silica.

Product Evaluation

The product was evaluated by chemical analysis, by X-ray comparison both with a sample of tricalcium silicate supplied by the Portland Cement Assn. and with data available in the literature, and by examination with a polarizing microscope.

Chemical Analysis

The oxide composition as determined by chemical analysis (ASTM Methods C 114-58⁴ and C 114-58T⁵) of the synthetic tricalcium silicate was as shown in Table II. From the oxide composition, the compound composition was computed to be as shown in Table III.

X-ray Examination

Table I shows X-ray data for three samples with Simons data taken from Heller and Taylor (8). X-ray spacings obtained at the Engineering Materials

TABLE I.—X-RAY SPACINGS FOR SYNTHETIC TRICALCIUM SILICATE.
(See Explanatory Notes on Next Page)

Portland Cement Sample	Assn. I	Authors' Samples, Flint d	Authors' Samples, Silicic Acid I	Simons Sample Data d	Indices and Intensities Calculated from Pseudocell
			(28.57) (24.77)		
11.04	1	11.12	<1	11.18	<1
5.95	3	6.00	3	5.97	3
5.50	<1	5.53	<1	5.53	<1
(4.90) ^a	<1				
		4.14	3	4.13	<1
3.91	6	3.91	7	3.91	7
3.76	3	3.76	3		
		3.70	3	3.73	2
3.56	4	3.56	3	3.56	4
		3.47	2	3.46	3
(3.38)	2	(3.40)	1	(3.39)	3
		3.32	1	3.32	3
3.28	4	3.28	3	3.27	5
		3.15	1		
3.054	51	3.058	59	3.056 ^c	54
2.978	16	2.986	22	2.982	19
2.900 ^a	1				
				2.891 ^a	w
				2.818 ^d	vw
2.794	100	2.798	100	2.794	100
				2.776 ^e	vs
2.769	64	2.769	80	2.769	70
2.746	42	2.748	51	2.746	44
				2.730 ^e	s
2.710	7	2.712	7	2.709	7
2.619	85	2.624	97	2.621	86
				2.602	vs
2.569	3	2.574	3	2.582	3
2.529	1	2.533	1	2.535	2
2.466	7	2.466	8	2.466	6
2.447	4				
2.409 ^f		2.428 ^f	3		
2.382	2	2.382	3	2.384	2
2.335	12	2.340	12	2.336	12
2.321	11	2.320	12	2.321	12
				2.304	mw
2.285	5	2.286	6	2.287	5
2.252	3	2.266	5	2.266	3
				2.251	2
2.192	49	2.198	51	2.195	48
				2.185	vs
2.170	12	2.174	17	2.176	11
				2.159	vw
2.135	3	2.137	3	2.136	3
2.102	4			2.116	2
2.092	4	2.097	3	2.091	4
2.051	1	2.055	1	2.052	2
2.022	2	2.017	2	2.021	2
1.989	10	1.994	9	1.988	8
				1.979	m/b
1.948	12	1.951	12	1.948	12
1.935	9	1.940	9	1.937	9
				1.940	ms
				1.926	m
1.915	3	1.916	3	1.920	3
1.868	<1				
				1.863	vw
1.832	7	1.835	8	1.834	7
				1.825	m/b
1.804	3	1.806	3	1.804	3
				1.797	w
(1.774)	26	(1.779)	31	(1.777)	28
(1.769)	27	(1.773)	30	(1.770)	28
(1.762)	26	(1.767)	29	(1.763)	27
				(1.752)	s
					22.0 vs ^g

Table I continued on next page

Laboratory for samples from subsequent burns are essentially identical.

In powder diffraction patterns, tricalcium silicate is identified by the presence of double or triple lines at $d = 1.468$, $d = 1.458$; at $d = 1.499$ and $d = 1.493$; at $d = 1.770$, $d = 1.764$, and $d = 1.707$ (10-12). The authors' samples and the sample from the Portland Cement Assn. all showed these lines and were thus interpreted as tricalcium silicate. None of the samples indicated conclusively the presence of dicalcium silicate.

Petrographic Examination

The samples made with flint and with silicic acid were examined in immersion media, a sample from the Portland Cement Assn. being examined at the same time. The two University of California samples were very fine grained, with the crystals ranging in maximum dimension from 4 to 80 μ , with the average nearer to the lower value. In the sample made with silicic acid, the predominant maximum dimension was near 12 μ . Both samples

³ Determined in accordance with Method of Test for Fineness of Portland Cement by Air Permeability Apparatus C 204-55, 1958 Book of ASTM Standards, Part 4, p. 140.

⁴ Standard Methods of Chemical Analysis of Portland Cement (C 114-58), 1958 Book of ASTM Standards, Part 4, p. 63.

⁵ Tentative Methods of Chemical Analysis of Portland Cement (C 114-58 T), 1958 Book of ASTM Standards, Part 4, p. 102.

TABLE I—X-RAY SPACINGS FOR SYNTHETIC TRICALCIUM SILICATE (Continued).

1.706.....	1	1.707 <1	1.708 <1	...	...	h
		1.664 <1	1.688 <1	...	...	21.10 vw
{1.648}.....	6	{1.650} 6	{1.648} 6	{1.642} vw		00.15 vw
{1.639}.....	23	{1.640} 24	{1.638} 23	{1.632} s		
{1.635}.....	18	{1.632} 12	...	{1.623} m		02.13 vs
1.630.....	13	...	{1.630} 13	...	...	...
		1.596 1	...	...	...	{12.11 vw
			...	...	...	{31.5 vw
1.547.....	16	1.574 1	1.574 <1	...	...	...
		1.550 15	1.549 15	1.543 m		20.14 vs
1.529.....	2	1.527 3	1.529 2	1.526 vw		40.1 w
			1.512 1	1.513 vw		04.2 vw
{1.499}.....	20	{1.499} 19	{1.499} 17	{1.497} m		...
{1.493}.....	19	{1.494} 20	{1.492} 20	...		...
{1.489}.....	19	{1.491} 20	{1.490} 20	{1.481} m		22.9 vs
1.473.....	4	1.474 4	1.475 5	...	...	...
1.468.....	5	1.469 6	1.468 6	1.466 w/b		...
1.458.....	3	1.459 4	1.458 4	...	...	...
1.457.....	3	...	...	1.454 w/b		...
1.437.....	<1	1.438 1	...	1.433 vw		...
1.410.....	1	1.410 2	...	1.409 vw		...
1.393.....	4	1.396 5	...	1.392 m		...

a C₂S.b $K\beta$ of 3.056 = 3.38; $K\beta$ of 3.022 = 3.344.

c Resolvable as a triplet; shown as triplet in Fig. 2, p. 33 of Jeffery (10).

d Not recognized on other patterns.

e Shown as doublet in Fig. 2, p. 33 of Jeffery (10).

f $K\beta$ of 2.195 = 2.429.

g This group resolvable as four lines in authors' samples, made with silicic acid; appears as triplet in Fig. 2, p. 33 of Jeffery (10).

h 1.701 Å is the second strongest line of CaO; however, 1.707-Å line is stronger than 2.405-Å line in these patterns; therefore, in all probability neither line is CaO.

NOTE 1.—The patterns obtained by Mrs. Mather at the Concrete Division of the Waterways Experiment Station for the Portland Cement Assn. sample and the authors' samples were all run with the samples ground to pass No. 325 sieve, mounted as tight-packed powders in aluminum holders, with operating conditions as follows:

Slit system: Below 20 deg 2-theta: beam 1 deg, soler 3 deg, detector 0.2 deg; above 20 deg 2-theta: beam 3 deg, soler MR, detector 0.2 deg.

KVP-50, MA-16; target, copper, angle, 4 deg; focal spot vertical; filter, 2 layers nickel foil.

Range: log 4000 time constant 30-74-N. Input sensitivity, v: Portland Cement Assn. 3.5; flint, 4.3; silicic acid, 4.3.

Reverter in at 95 per cent (Portland Cement Assn.); 94 per cent (flint and silicic acid).

Scanning speed: 0.2 deg per min.

Date: Portland Cement Assn., Sept. 4, 1957; flint, July 1, 1958; silicic acid, Aug. 4, 1958.

All samples had maximum particle size probably well below 20 μ .

NOTE 2.—All three samples were rerun in the range from 20 to 68 deg 2-theta, with operating conditions as above except that the 0.1 detector slit and the HR soler were used and the paper speed adjusted to give 1 deg per in. (12 in. per hr) at scanning speed 0.2

deg per min. These conditions suppress the weak lines and resolve doublets at 3.05, 2.98, 2.768 and show that the complex from 1.648 to 1.630 Å is at least 4 lines.

NOTE 3.—Simons' spacings from L. Heller and H. W. F. Taylor (8), modified by data from Jeffery (10). Indices and intensities calculated by Jeffery for the rhombohedral pseudocell, quoted by Heller and Taylor, matched by Mrs. Mather to the lines she believes they correspond to.

NOTE 4.—Simons' spacings and the Mather spacings differ, with the difference greatest at low values of 2-theta, diminishing toward higher values. Simons used a 19-cm camera and presumably a rod or capillary specimen. The use of a flat plate of powder, as in a diffractometer, gives a displacement of the center of gravity of the line, toward lower theta values, of one third of the geometrical width of the line. The expression for this is $(\delta^2 \cot \theta)/3$, in which δ is half the horizontal divergence of the incident beam. G. W. Brindley, (13) states that the front face of the Concrete Division specimens is also back of the center of the spectrogoniometer.

NOTE 5.—Intensities on the three patterns run at the Concrete Division were obtained as follows: Peak height and background were read from the ratemeter charts using a ratemeter calibration scale. The quantity, peak height minus background, for each peak, was expressed as a percentage of the intensity of the peak at 2.794 Å.

had indices of refraction of about 1.720 ± 0.005 at 25 C. The available liquids were spaced at index intervals of 0.01; the samples were closer to 1.720 than to 1.710 or 1.730. No other phases were detected, and both samples appeared to be very uniform. The sample from the Portland Cement Assn. was more coarse grained, with many crystals around 30 to 40 μ . The crystal outlines were much better developed than in the two University of California samples. Many of the crystals had low-index coatings, probably representing hydration in moist air. A few crystals showed gas bubble inclusions and low-

index inclusions; there was a very small amount of calcium carbonate and of some phase with moderate birefringence.

Differential Heating Curves

Differential heating curves of the present sample are compared in Fig. 4 with the curve published by Jeffery (10), based on work by R. W. Nurse and J. H. Welch, for synthetic, "pure" tricalcium silicate. Jeffery states that the break at 464 C is characteristic of preparations containing finely dispersed calcium oxide and probably arises from loss of water from the surface of CaO grains; that the breaks

TABLE II.—OXIDE COMPOSITION OF SYNTHETIC TRICALCIUM SILICATE AS DETERMINED BY CHEMICAL ANALYSIS.

Oxide Constituent	Amount in Clinker, per cent by weight ^a
SiO ₂	26.20
CaO (combined).....	73.40
CaO (free).....	0.06
Al ₂ O ₃	0.11
Fe ₂ O ₃	0.02
MgO.....	0.09
Na ₂ O, K ₂ O.....	0.00
Loss on ignition.....	0.12

^a Observed total, 100.09 per cent; all observed values corrected in proportion to yield total of 100.00 per cent.

TABLE III.—COMPOUND COMPOSITION AS COMPUTED FROM OXIDE COMPOSITION.

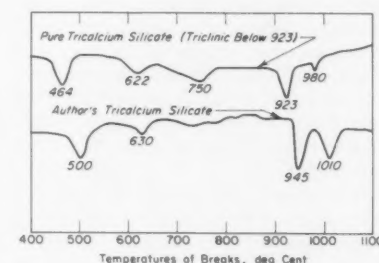
Compound	Amount in Clinker, per cent by weight
3CaO·SiO ₂	99.1
2CaO·SiO ₂	0
3CaO·Al ₂ O ₃	0.2
4CaO·Al ₂ O ₃ ·Fe ₂ O ₃	0.4
MgO, free CaO, and loss on ignition.....	0.3

at 622 and 750 C may be due to the β - α' and γ - α' transformations of dicalcium silicate. He assumes that the remaining breaks at 923 and 980 C arise from transformations within the tricalcium silicate.

The lower curve of Fig. 4 was obtained from the differential heating of the authors' tricalcium silicate. It shows breaks at 500, 630, 945, and 1010 C, corresponding respectively to those shown by Jeffery at 464, 622, 923, and 980 C. No break corresponding to the γ - α' transformation in the neighborhood of 750 C is apparent, however, indicating that dicalcium silicate resulting from the dissociation of tricalcium silicate on heating into dicalcium silicate and free lime, if present, was present in the β form only. Otherwise, the two samples are quite similar.

Summary

Easily ground, high-purity triclinal tricalcium silicate can be produced in



Note—Data for upper curve taken from Jeffery (10), Fig. 9, p. 45.

Fig. 4.—Differential heating curves for tricalcium silicate.

two burns, one at the relatively low temperature of 1450 C, and one at the high temperature of 1650 C, without any intermediate grinding. The product is low (0.06 per cent) in free lime, and essentially free of dicalcium silicate as shown by chemical analysis and X-ray diffraction. Pure triclinic C_3S was the product, as shown by the X-ray results.

The initial high purity is attributed to the careful selection and handling of raw materials and hearth material; this purity is maintained because intermediate grinding of the clinker, and therefore contamination by attrition in the mill, is eliminated by the presence of an amount of free lime sufficient to disrupt the clinker structure when it is gaged with water after the preliminary burn.

The possibility has been considered of using reagent-grade calcium hydroxide of very low alkali content in place of calcium carbonate as a source of lime in order to eliminate the preliminary firing which serves primarily to dissociate the calcium carbonate. With calcium hydroxide as a raw material, active lime becomes available at a lower temperature than in the case of precipitated calcium carbonate.

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A Survey of Infrared Inspection and Measuring Techniques

By DAVID K. WILBURN

INDUSTRIAL applications of infrared radiation were, until pre-World War II times, limited to such commercial practices as cooking and heating or the more cunning processes of infrared photography or remote temperature sensing. However, in 1940, the infrared spectrometer became an accepted industrial instrument, and it was apparent that a new technology had been developed. Today, thousands of infrared spectrometers are employed for the nondestructive and quantitative identification of chemical and biological compounds. Infrared also finds use in the automatic monitoring of processes, the manufacture of textiles and plastics, in pharmaceuticals and medicine, and in

other organic and inorganic processing fields.

The basis for the military interest in infrared is simply that any object at a temperature above absolute zero and having an emissivity above zero radiates electromagnetic energy, much of which is in the infrared zone. Thus, all objects from stars to aircraft to human

beings are natural radiators and can be detected by means of suitable instrumentation.

This military interest has resulted in the development of more sophisticated systems and components, which are slowly becoming available for commercial application. Therefore, the use of infrared as a means of nondestructive

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testing need not be limited to techniques of spectrographic analysis but can take advantage of these newly developed systems and components to perform a variety of inspection and measuring tasks.

Nature of Infrared

Infrared energy and its interaction with matter represents a branch of physics that is rapidly expanding into a characteristic technology. The infrared portion of the electromagnetic spectrum can be found between the visible on one side, and extremely short radar transmission on the other side. Figure 1 depicts the generalized spectrum of electromagnetic radiations and a breakdown of the infrared portion. Infrared is categorized into three segments: The near, from 0.7 to 1.5 μ ; the middle, from 1.5 to 5.5 μ ; and the far, from 5.5 to 20 μ .

All objects in the universe that are not at absolute zero radiate energy in the form of electromagnetic waves. The relative distribution of this energy emitted from an ideal radiator, known as a "black body," is a function of source temperature and is characterized by the typical waveforms shown in Fig. 2. It can be noted that the peak of the radiation curve moves toward the shorter wavelengths as black-body temperature is increased.

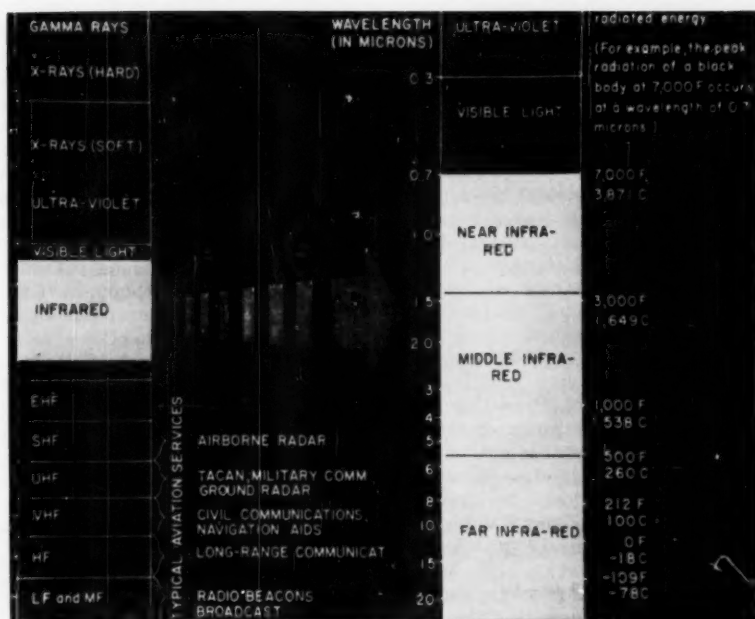
In addition to the fundamental laws of radiation, there are several other physical entities which must be considered before the systems design engineer can employ infrared as a nondestructive testing medium.

Ordinary optical materials cannot be used to refract or transmit infrared. In common use are synthetic single crystals, such as rock salt, or optical grades of the more complex semiconducting materials, such as silicon and germanium. The following table lists several of the more simple optical materials used in infrared and their recommended range of usefulness.

Material	Recommended Wavelength Range, μ
Glass.....	0.3 to 2
Quartz.....	0.3 to 3.5
LiF.....	0.2 to 6.0
Fluorite.....	0.2 to 9.0
NaCl.....	2 to 15
KBr.....	12 to 25
KRS-5.....	2 to 40
BaF.....	2 to 13
CsBr.....	15 to 38

In addition, first-surface aluminized mirrors are used as reflecting optics in focused systems not requiring refractive elements.

Perhaps the most important component of an infrared system is its detector, or transducing element, which converts the infrared signal into some usable elec-



U.S. Army Photograph

Fig. 1.—Spectrum of electromagnetic radiation.

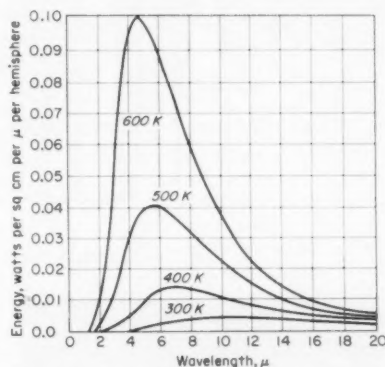


Fig. 2.—Spectral distribution of energy for perfect emitters.

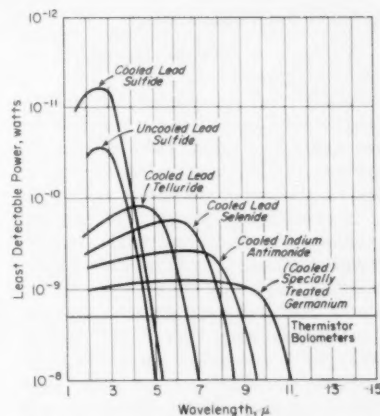
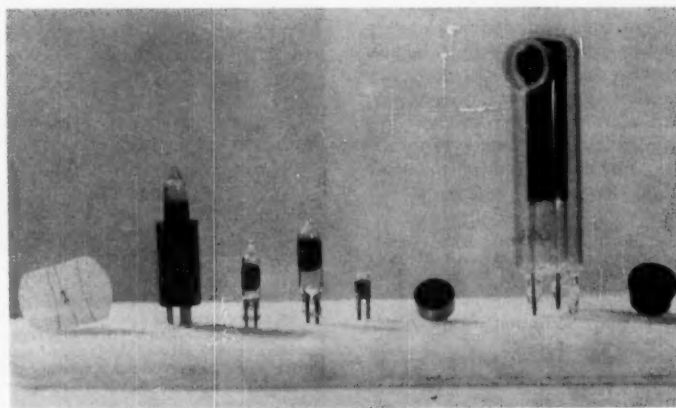


Fig. 3.—Spectral sensitivity of several infrared detectors.



U. S. Army Photograph

Fig. 4.—Various photoconductive detectors of the film type.

trical quantity. Detectors are fundamentally of two types: The thermal detector, which uses the heating effect of infrared, and the photo detector, which depends upon an absorption of the radiation flux into the electronic structure of the detector element. Figure 3 depicts two of the most important characteristics of detectors—their spectral response and relative sensitivity. Typical of the thermal detectors are thermocouples or bolometers and, of the photo-type devices, photoconductive, photovoltaic, and photoelectromagnetic detectors. Figure 4 shows various photoconductive detectors of the film type.

The transmission of infrared through the atmosphere is also an important aspect of system utilization in nondestructive testing. Normal atmosphere exhibits certain "windows" or areas of high transmission. Figure 5 illustrates infrared windows in the wavelength range 1 to 14 μ .

From this very brief résumé of some of the more prominent aspects of this new technology, it should be apparent that a certain continuity exists between detector, source, transmitting media, and optical materials.

Infrared Instrumentation

A certain amount of commercial infrared instrumentation is presently available for performing nondestructive tests on materials or finished components. This apparatus may be categorized as (1) image-forming systems, and (2) the radiometer detector.

Infrared image-forming systems are capable of producing a visible, two-dimensional image representative of the thermal conditions of the scene under view. Such devices operate without illumination and "see" the emitted energy of the target, or under some circumstances, difference in emissivity. Several typical "heat pictures" are shown in a paper by Overbo, et al.¹

In comparison, radiometers collect the infrared radiations in a narrow field of view and focus the resultant energy onto a detector. The detector or sensing element then converts this energy into a proportional electrical signal. Remote temperature measurement by radiometric techniques is a well-known art, often referred to as pyrometry.

A type of image-forming system not described previously, but of practical use in nondestructive testing, is the

¹ P. J. Overbo, R. R. Sawyer, R. H. Ostergren, R. W. Powell, and E. L. Woodcock, "Industrial, Technical, and Medical Applications of Infrared Techniques," *Proceedings, Inst. of Radio Engineers*, Vol. 47, pp. 1629-1645 (1959).

² F. J. Filippi, "Quantitative Analysis of Braze Sandwich," *Journal, Soc. for Nondestructive Testing*, Vol. 17, pp. 39-45, Jan.-Feb., 1959.

³ R. C. McMaster, A. T. D'Annese, and H. W. Babel, "Evaluation of Braze Honeycomb Structures," *WADC Technical Report 60-393*, Wright Air Development Div., pp. 270-278, Sept., 1960.

evaporograph. This device, originally intended for military use, has been found most profitable in the industrial and medical fields. In operation, the system gathers infrared radiation from the field under view and forms a thermal image on an internal membrane. A special coating on the front surface of the membrane absorbs this radiation and changes temperature from area to area in accord with the amount of radiation received from the target. These surface variations in temperature are resolved into differences in oil thicknesses that cause light reflected off the surface to give rise to a visible colored thermal image of the object under view. These colors are actually interference patterns and are representative of thermal gradients or temperature.

Infrared Techniques of Nondestructive Testing

Perhaps the most impressive use of infrared as a means of nondestructive testing is in the possible location of flaws and imperfections in materials. One reported application² is in the inspection of brazed sandwich honeycomb construction materials.

Thermographs of sandwich panels indicate the degree and uniformity of bonding between honeycomb sections as a function of heat transfer. Thus, improperly bonded sections are shown as areas of low thermal conduction in the "heat picture" of the panel under test. A summary of the various thermal and infrared test methods for brazed and welded shapes is presented in a paper by McMaster, et al.³

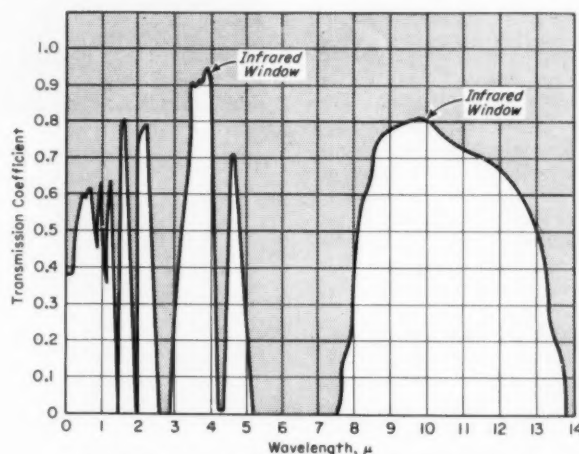
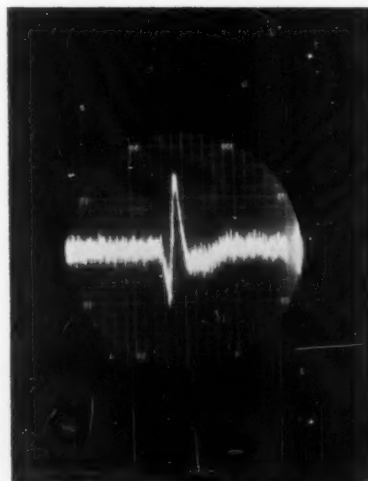


Fig. 5.—Transmission spectra of the atmosphere.



U. S. Army Photograph

In this oscilloscope presentation, the horizontal axis represents distance across the face of the specimen. The vertical axis represents the relative intensity of the infrared radiation emitted by the specimen 1 min after thermal shock. The pulse in the center represents the flaw.

Fig. 6.—Line-scanned thermographic profile of defect in polyurethane insulation.

The evaporograph has also been used to locate and observe flaws in assemblies and materials by observing the infrared emitted by the object under test. However, regardless of what form of instrumentation is used to produce a thermograph, it is important that the object under examination provide a suitable radiation signal. This signal is not only dependent upon the temperature of the test object, but also the emissivity. That is, if the temperature is low, the signal-to-noise ratio between background radiation and target radiation will make it difficult to discern a flaw. Similarly, if the emissivity of the test object is low, radiations from extraneous sources may be reflected from test object surfaces, thus producing errors in observation.

The importance of producing a temperature differential in the object under view is a necessary requirement in providing a suitable target for thermographic observation. However, the temperature limitations of the material must be considered. Temperature differences are usually established by heating one surface of the object and cooling

the other. Interior defects and flaws are then characterized by a change in thermal conductivity in the immediate area of the flaw. Heating and cooling must be applied in a uniform manner to avoid false gradient indications.

Some methods that can be used to heat a panel-type object are:

1. Heat lamps,
2. Hot-water or oil baths,
3. Circulation of hot air,
4. Electrical resistivity, and
5. Conduction and convection.

Once a thermal gradient has been established, two techniques may be used in making the inspection. If the general location of the flaw is known, such as a welded seam, a radiometer may be used to view the suspected area. However, in large sections, such as bonded laminates, honeycomb, or structurally formed materials, it is generally necessary to locate an area where a flaw is present. Once this has been accomplished, this area can then be examined in minute detail. Infrared imaging devices are therefore more applicable in surveillance of large areas of suspected flaws, whereas radiometers with limited fields of view may be used in inspection of minute areas of known or suspected defect.

Where areas of suspected defects are localized, such as butt welds, linear laminations, or seam structures, a slightly different technique may be used in inspection, that is, the use of a line-scan mirror system which will see only along a scanned line. This device can then be used to traverse the area under inspection, seeing only an element of narrow width. A one-dimensional thermographic profile of a material discontinuity is shown in Fig. 6. In this illustration a line-scanning radiometer was used to view a $\frac{1}{2}$ -in. thick panel of polyurethane insulation having $\frac{1}{8}$ -in. defect. The panel was shocked thermally to produce a temperature gradient representative of the internal structure of the material.

Since most thermal imaging devices have a minimum frame period, that is, the time necessary to generate one complete picture, it is necessary to maintain a constant thermal equilibrium of the specimen. Typical are minimum frame periods of approximately 15 sec. However, most mechanical scanning devices require from 2 to 5 min to complete a frame with maximum resolution and sensitivity. Military developments, however, are constantly striving for reduced frame periods and greater resolution and sensitivity.

⁴ G. V. Thompson, "How to Find Airframe Material Emissivity," *Aviation Age*, Vol. 29, pp. 68-71, May, 1958.

The two physical properties of a material that can be used to enable infrared inspection are conductivity and thermal capacity. If conductivity exists within a sheet of material, a forced heat applied to one face will cause a thermal transfer to the opposite face. Further, the conductivity between adjacent unit areas will differ as a function of any obstruction between these areas. Since the presence of a flaw will produce a cooler or hotter region on the surface adjacent to the flaw, a temperature pattern should result that is characteristic of internal discontinuities. To enhance this effect, heat can be removed by cooling from the surface opposite the face that is heated.

The thermal capacity or specific heat of a material may also be used to locate and measure faults in a solid. In this case it is assumed that the thermal capacity of a material is different in areas containing flaws. If, then, the test specimen is placed either in an extremely cold or hot environment, each unit area will exhibit a rate of thermal change. This is a transient condition which exists only a few moments after the specimen is thermally shocked. As equilibrium is reached, this temperature pattern will disappear.

Infrared Capabilities of Inspection and Measurement

In addition to the previously discussed general techniques of infrared inspection, there are several other possibilities for specialized infrared nondestructive tests and measurements. These may be classed as (1) the measurement of physical quantities in absolute or arbitrary units, and (2) the measurement of some parameter or quality in a material or component.

Typical of class 1 measurements would be the direct analysis of surface emissivity in metals. This has been reported by Thompson,⁴ who computed the emissivity of airframe materials by use of a twin radiometer device, called an integrated emissometer.

In addition to the property of emissivity, it should also be possible to measure physically the quantities shown below.

In meteorology, infrared has been

used to measure absolute humidity, and has found special use in upper-atmosphere research.

Similarly, infrared has been used to measure qualitative class 2 parameters of materials and components. Examples of such are numerous.

A refrigerator manufacturer uses infrared to isolate voids and flaws in polyurethane insulation. An aircraft company has made use of infrared to locate points of metal working, and stress and strain in missile hardware by detecting the minute increases of temperature generated at these points.

In medicine, near-surface abnormal growths such as tumors and cancers have been detected and localized by infrared diagnostic techniques. This is possible since the malignant areas are at a slightly higher temperature than adjacent normal skin.

Electrical power transmission lines are being inspected by infrared radiometric apparatus. There, faulty connections develop excess heat which is easily detected. Overheated transformers are also located by this method.

Summary

A brief survey of the present "state of the art" of infrared methods of inspection, analysis, and measurement has been presented. Many physical quantities and natural properties of materials may be measured by infrared, utilizing some form of emission, absorption, reflection, refraction, polarization, or scattering. Although the most universal application of infrared has been spectroscopy and remote temperature sensing, a great deal of work is now being done in the field of inspection, testing, and measurement. Although research can be initiated in these fields through use of commercially available equipment, many applications require specially fabricated devices. This, of course, requires an understanding of the nature of infrared and a knowledge of available detectors, infrared materials, and optics. Although the acceptance of infrared as a basic technique has lagged behind other more conventional means of inspection, such as radiography, this technology is supplementing the more widely accepted methods.

Physical Quantity	Property To Be Measured
1. Thermal conductivity.....	The number of calories of heat that will flow per second through a square inch of surface, 1 cm thick, when the opposite faces of the square are at a temperature difference of 1 C.
2. Heat of combustion.....	The number of heat units which a unit mass of material will yield when burned.
3. Thermal capacity.....	The number of calories required to raise the temperature of a mass of substance 1 C.
4. Specific heat.....	The ratio of the thermal capacity of a mass of substance to the thermal capacity of an equal mass of water.

Apparatus for Controlled Slack Quenching

By N. L. CARWILE, M. R. MEYERSON, and S. J. ROSENBERG

IN THE hardening of steel, it is usually desired that the entire cross-section be transformed fully to martensite prior to tempering. Such a microstructure (tempered martensite) gives the best combination of strength and ductility. As section size increases, however, higher and higher concentrations of alloying elements are needed in the steel in order to increase the hardenability, otherwise nonmartensitic products will be present in the quenched steel. Even with a high alloy content, it is not always practicable to fully harden many steel components because of physical and economic limitations. The term "slack-quenched" has been used to define such an incompletely hardened steel.

Steels are often used in the slack-quenched condition even though the mechanical properties of the slack-quenched structures are not known. The main reason for the lack of information in this field has been the difficulty of controlling the slack-quenching operation so as to obtain uniform microstructures in incompletely hardened specimens.

Vajda and Busby (1,2)¹ studied the effect of slack quenching using specimens from end-quenched 7-in. rounds. It is evident that this required a considerable mass of steel, and the resultant specimens still were not uniform in microstructure throughout the cross-section. A simple end-immersion method was subsequently devised at the National Bureau of Standards for producing slack-quenched impact specimens (3). This procedure developed any desired slack-quenched microstructure in the central area of the specimens.

A logical approach to the development of slack-quenched tension specimens appeared to be some modification of the end-immersion procedure successfully used for impact specimens. It was anticipated that by quenching both ends of a specimen blank simultaneously and at the same rate, a uniformly slack-quenched central area could be obtained.

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¹ The boldface numbers in parentheses refer to the list of references appended to this paper.

A newly developed apparatus and technique that produce any specified slack-quenched structure in a cylindrical specimen of a steel of medium hardenability is described. The method is rapid, easily reproducible, and relatively inexpensive. It may be used to produce slack-quenched structures in tension, impact, fatigue, or other test specimens. Some data are presented to show the effectiveness of the apparatus and technique and the influence of different degrees of slack quenching on the tensile properties of AISI 9440 steel.

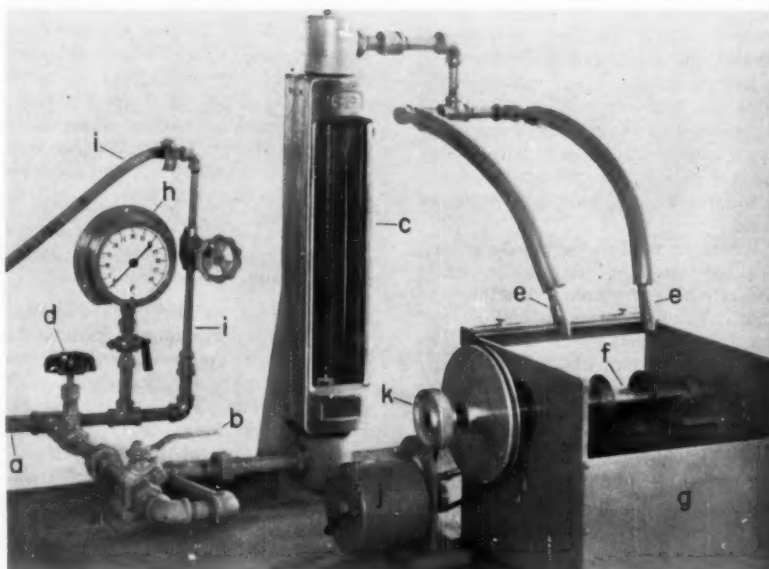


Fig. 1.—Apparatus for slack-quenching tension blanks.

NESBIT L. CARWILE, a metallurgist in the Thermal Metallurgy Section, has been at the National Bureau of Standards, Washington, D. C., since 1937, and has conducted research studies on deformation of metals at high and low temperatures, and hardenability of steel.

MELVIN R. MEYERSON received a B.S. in metallurgical engineering from the Virginia Polytechnic Inst. in 1942 and a master's degree in metallurgy from the University of Maryland. He has been a metallurgist at the National Bureau of Standards since 1946, where he is currently studying the influences of structural transformations and residual stresses on the dimensional stability of metals and the effects of slack-quenched structures on the properties of steels.

SAMUEL J. ROSENBERG, metallurgist, National Bureau of Standards, is a mechanical engineering graduate of the George Washington University, 1924. His early work was concerned chiefly with the wear of metals. More recently he has been concerned with the heat treatment and properties of steels, particularly high-strength and stainless steels.

The present paper describes a newly developed apparatus and technique which produce the desired slack-quenched structure in a standard round tension specimen and also can be used with equal facility to produce slack-quenched structures in impact or round fatigue specimens. The steel blanks required are solid cylinders, obtainable in any orientation from bar, plate, castings, or other sources. Some data are also presented to show the effectiveness of the apparatus and technique.

Description of Apparatus and Specimen Blank

The quenching apparatus developed for slack-quenching blanks for tension specimens is shown in Fig. 1. Water, at any desired temperature, is pumped through pipe *a* from a storage tank to commence the cycle. Flow can be started and stopped quickly by a 90 deg turn of the on-off valve, *b*. Rate of flow is measured by the flowmeter, *c*, and is preset before every run by adjusting the globe valve, *d*, located just ahead of the on-off valve. The water flows equally through the two nozzles, *e*, which are mounted on flexible metal hose for vertical and lateral adjustment, impinges near the ends of the specimen blank, *f*, and runs off through an antisplash screen to the bottom of the assembly tank, *g*, where it drains through a hose and returns to the storage tank. A pressure gage, *h*, indicates the water pressure in the system, and an overflow line, *i*, is always kept slightly open to permit some water flow and thereby reduce back pressure when the on-off valve, *b*, is closed. An electric motor, *j*, supplies power to turn the shaft which rotates the blank at 300 to 350 rpm. The blank is suspended between two metal cups, one of which is driven and rotates the blank through a spring-loaded friction connection, while the other rotates with the blank. The knob, *k*, is free-turning and is used to retract the driving shaft and cup, during rotation, to permit insertion of the hot specimen blank. The V-shaped bars at the ends of the specimen blank act as guides for rapid insertion of the hot blank; the guide on the left end also serves as a stop for the spring-loaded cup when no blank is in place. The details of the rotating retractable shaft and the cups are shown in Fig. 2. The V-shaped guide bars are omitted to avoid complicating the drawing.

The operation of the assembly is as follows: About 20 gal of water at the specified temperature is placed in the storage tank and the pump is started. On-off valve *b*, Fig. 1, is opened, and the flow of water is adjusted by means of valve *d* and flowmeter *c*. The desired vertical and lateral adjustments of the nozzles, *e*, are made. The motor, *j*, is started, and when the specimen blank is

ready for removal from the furnace, the on-off valve, *b*, is closed. The rotating shaft is retracted by means of the knob, *k*, the specimen blank is quickly inserted between the cups by a second operator, the knob is released to permit the shaft to spring back into operating position, and the on-off valve, *b*, is quickly opened. Water immediately strikes the rotating specimen blank near its ends, and flow is continued until the blank reaches the temperature of the water. The entire procedure, from the time of removal of the specimen from the furnace to the time that the water jet first strikes the rotating specimen, can be accomplished easily in 3 to 4 sec.

A specimen blank is shown in Figs. 1 and 2. The blanks selected were 6 in.

long and $\frac{3}{4}$ in. in diameter, but this is arbitrary and other convenient sizes can be used. The two steel collars shown on the specimen shield the central portion from the water, and they also may be used to control the rate of cooling by adjusting the distance between them. The shape of the collars is important in preventing water from reaching the center of the specimen, and a satisfactory shape was selected (Fig. 2) only after trying many previously unsatisfactory geometries. The collars finally used had an outside diameter of 2 in. and a thickness of $\frac{1}{8}$ in. They are attached to the specimen blank with a small amount of high-temperature cement (Sauerisen No. 32) and are heated with the specimen during austenitizing. The cement is partially

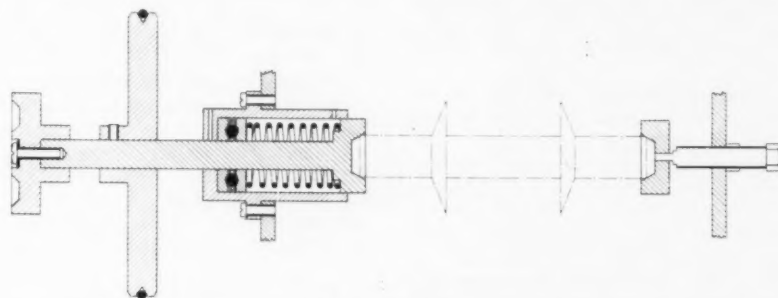
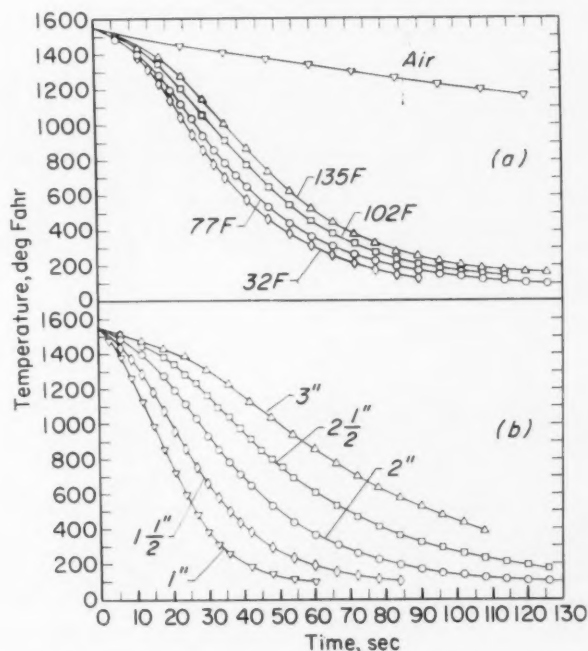


Fig. 2.—Details of the retractable shaft of the slack-quenching apparatus. Dashed lines are the specimen blank and attached collars.



(a) Effect of water temperature. Numbers on curves indicate temperatures of quench-water. Water flow and collar spacing were held constant (1.0 gal per min and 2 in., respectively).
(b) Effect of collar spacing. Numbers on curves indicate distance between collars. Water flow and water temperature were held constant (1.0 gal per min and 77 F, respectively).

Fig. 3.—Effect of variations in water temperature and collar spacing on the cooling rates of ingot iron blanks. The cooling curve for an air-cooled specimen is included in (a).

softened by the water during the quench, and the collars are easily removed for reuse.

Control of Cooling Rates

It is obvious that control of slack-quenched structures can be obtained only by controlling the rate of cooling throughout the cross-section of a steel specimen blank. In the quenching apparatus described, four different methods of controlling the cooling rate may be used: (1) varying the temperature of the quench water; (2) changing the rate of flow of the quench water; (3) adjusting the distance between the two collars on the specimen blank, and (4) using a quenching medium other than water, such as a brine solution. The first three of these methods were investigated. In these tests, open-hearth ingot iron blanks were used in order to avoid the extraneous heat effects of a structural transformation on the cooling curve.

Cooling curves were obtained by use of a thermocouple and a high-speed potentiometer-type recorder. The thermocouple was 30-gage chromel-alumel, insulated with a ceramic material and sheathed in type-310 stainless steel (the outside diameter of the entire thermocouple assembly was only $\frac{1}{16}$ in.). The beaded end of the thermocouple was pressed into a $\frac{1}{16}$ in. hole drilled into the specimen at a point equidistant from each end and extending from surface to axis. A slight peening of the surface of the specimen around the thermocouple sheath was required to prevent the thermocouple from shifting during handling. In the procedure for measuring cooling rates, it was necessary to modify the motion of the specimen in the slack-quenching fixture since the specimen could not be freely rotated with the thermocouple attached. As a substitute, the specimen was oscillated through 120 deg at approximately 100 cycles per min. Although this introduced an undesired variable, its effect on cooling rate was considered small and the relative influences of the above three methods of varying the cooling rate could be established with considerable precision.

The cooling curves obtained are shown in Fig. 3. All ingot iron specimens were heated to 1700 F, and the zero time for cooling was plotted as the point on the recorder chart where the temperature reached 1550 F. For purposes of comparison, a cooling curve obtained by cooling a specimen in air is included in Fig. 3. It is apparent that

the air cooling can have only negligible effect upon the water-quenched specimen blanks.

The influence of the temperature of the quenching water is shown in Fig. 3 (a). In each test, water flow was maintained at 1.0 gal per min and the collars were spaced 2 in. apart.² Water temperatures studied were 32, 77, 102, and 135 F. As shown, the cooling rate in the range of 1300 to 900 F increased as the temperature of the water was lowered, but the change in rate was small.

The effect of rate of flow of water on cooling rate was determined with a water temperature of 77 F and a collar spacing of 2 in. No difference in cooling rate could be ascertained with flow rates of 0.7, 0.8, 0.9, and 1.0 gal per min; this procedure was considered ineffective for varying the cooling rates. The cooling curves obtained were similar to the curve designated 77 F in Fig. 3 (a).

The greatest control and range of cooling rates was obtained by adjusting the distance between the collars on the specimens (Fig. 3 (b)). These cooling curves were obtained with water at 77 F, a constant flow rate of 1.0 gal per min, and collar spacings ranging from 1 to 3 in. Intermediate cooling rates, and the

required spacings for them, can be obtained by suitable interpolation. This method proved highly reproducible; duplicate runs yielded nearly identical cooling curves.

In some steels of moderately high hardenability that are normally quenched in oil, cracking was observed at the ends after quenching with water. The use of cups to grip the specimens, as described, instead of the pointed centers originally used; the use of beveled edges on the specimen blanks instead of sharp edges; and the elimination of markings on the ends of the blanks eliminated most of the trouble. The cracking was eliminated entirely by raising the temperature of the water to the higher level (135 F).

Microstructure and Hardness

The AISI 9440 steel selected for evaluating the apparatus had the following composition (per cent by weight): 0.42 carbon, 1.23 manganese, 0.029 phosphorus, 0.025 sulfur, 0.44 silicon, 0.31 chromium, 0.47 nickel, 0.13 molybdenum. It is a steel of medium hardenability with a Jominy curve as shown in Fig. 4. Specimen blanks were austenitized at 1525 F and quenched in the apparatus with the collars on each blank spaced at different intervals. Water temperature was maintained at 135 F and the flow at 1.0 gal per min. Each quenched blank was stress relieved $1\frac{1}{2}$ hr at 275 F,³ ground flat along the length of the cylindrical surface to a depth of 0.015 in., and surveyed for hardness along the ground surface. The results of the survey on four blanks are given in Fig. 5. The central position (0 distance) is the midpoint between the two collars.

When a blank was almost fully hardened (slightly slack-quenched) the

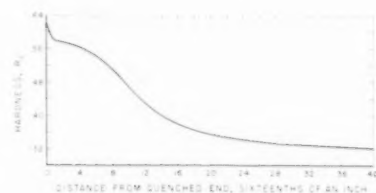


Fig. 4.—Jominy hardenability curve for the AISI 9440 steel austenitized at 1525 F for 30 min.

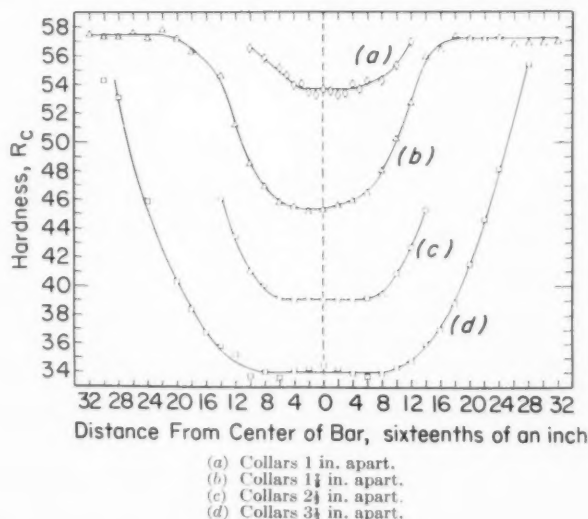


Fig. 5.—Influence of collar spacing on the hardness along the length of slack-quenched AISI 9440 steel blanks, $\frac{3}{4}$ in. in diameter, austenitized at 1525 F. Water flow and water temperature were held constant. (1.0 gal per min and 135 F, respectively.)

² Collar spacing reported throughout this paper is the distance between the interior facing surfaces of a pair of collars. (See Fig. 2.)

³ The stress-relieving treatment was applied to all specimens after hardening to minimize subsequent cracking of the ends during machining. It did not materially soften any of the slack-quenched structures.

zone of uniform hardness (within ± 1 Rockwell C scale (R_c)) was rather short (about $\frac{3}{4}$ in., curve *a*, Fig. 5). As the degree of slack quenching increased, zone of uniform hardness also increased (curves *b*, *c*, and *d*). Therefore, a gage length of $\frac{3}{4}$ in. was considered satisfactory for the tension specimens regardless of the degree of slack quenching. Obviously, longer gage lengths can be used with specimens subjected to increasing amounts of slack quenching.

The uniformity of structure throughout the cross-section of the 6-in. blank was determined by hardness tests and metallographic examination. The results of hardness surveys on two blanks of 9440 steel are shown in Fig. 6, one taken from a blank quenched with collars 1 in. apart, and the other quenched with collars $3\frac{1}{4}$ in. apart. Variations in hardness across such a section (except the decarburized surface, which was removed during machining) were generally less than $\pm 1\frac{1}{2} R_c$. A large portion of the indicated scatter is attributed to the appreciable ferrite banding observed in this steel. Photomicrographs taken at intervals along the axis of one of these blanks (*b*, Fig. 6) and others taken on a single plane (hardness 45 R_c) perpendicular to the axis are shown in Fig. 7. A continuously increasing amount of martensite is apparent as the axial distance from the center increases (top row of photomicrographs). A high degree of uniformity of structure from axis to a point near the surface in the cross-section of uniform hardness is indicated by the set of photomicrographs at the bottom of the figure.

Typical Results

As an illustration of the usefulness of the apparatus, some data are presented to indicate the effect of slack quenching upon the tensile properties of the 9440 steel.

After heat treatment all blanks were machined into round tension specimens 0.252 in. in diameter with a reduced section $1\frac{1}{4}$ in. long. In this diameter, the variation in hardness from axis to surface was within $\pm \frac{3}{4} R_c$. However, the ends were threaded (10 threads per in.) on the full $\frac{3}{4}$ in. diameter because of their high hardness and brittleness. Tension tests, at a rate of 0.02 in. per in. per min, were made on all specimens at room temperature, using SR-4 strain gages of 1-in. gage length.⁴

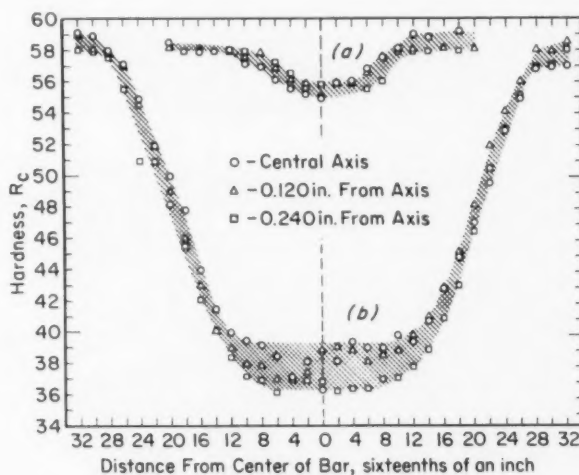
Blanks were slack-quenched with water at 135 F and a flow of 1.0 gal per

min to hardness levels of 45, 37.5, 35, and 33.5 R_c and stress relieved by heating at 275 F for $1\frac{1}{2}$ hr.

The results of tension tests are summarized in Fig. 8 (*a*). Both tensile and yield strengths increased as the proportions of slack-quenched structure decreased (hardness increased); this increase in strength was accompanied by a corresponding decrease in ductility.⁵

Additional blanks of the steel were slack-quenched to produce hardness values of 56, 50, and 45 R_c . At 56 R_c

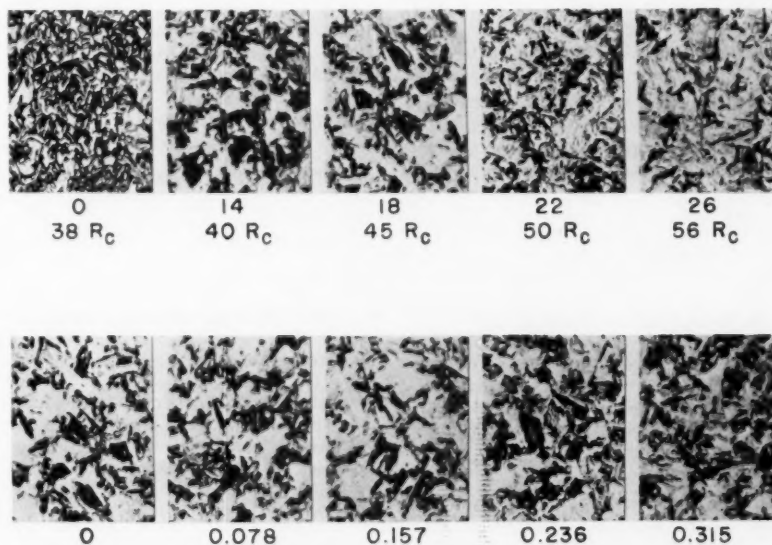
this steel is essentially fully hardened. The blanks with the higher hardnesses (56 and 50 R_c) were tempered to a hardness of 45 R_c and the results of tension tests made on specimens of the above dimensions prepared from the blanks are given in Fig. 8 (*b*). The tensile strength was relatively unaffected by these variations in heat treatment, but yield strength and ductility were considerably reduced as the amounts of slack-quenched structure increased. It should be pointed out, however, that



(a) Collars spaced 1 in. apart.

(b) Collars spaced $3\frac{1}{4}$ in. apart.

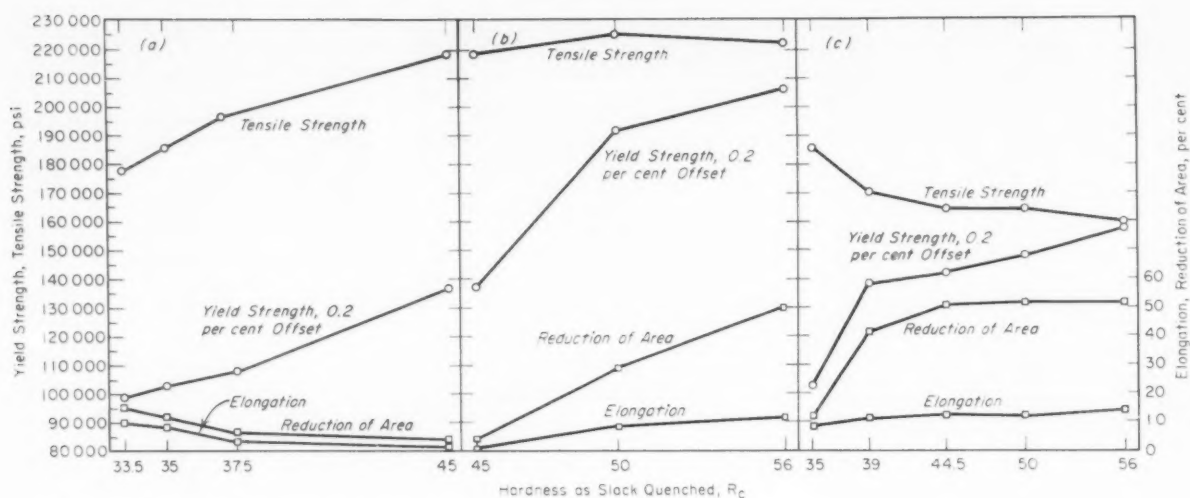
Fig. 6.—Variation of hardness through cross-section of slack-quenched AISI 9440 steel specimens, $\frac{3}{4}$ in. in diameter, austenitized at 1525 F. Water flow and water temperature were held constant (1.0 gal per min and 77 F, respectively).



(Top row) Numbers indicate distances from center along the axis in sixteenths of an inch, and corresponding hardness values.

(Bottom row) Numbers indicate distances in inches from axis toward surface. Areas shown are in a plane perpendicular to the axis that has a hardness of 45 R_c . This plane is located $\frac{15}{16}$ in. from the center of the blank.

Fig. 7.—Variation of structure along the length (top row) and through cross-section (bottom row) of a slack-quenched blank (Specimen *b*, Fig. 6). Etched with 1 per cent nital ($\times 500$). Reduced one third in reproduction.



(a) Specimens not tempered except for a stress relief at 275 F.
(b) Specimens tempered to and tested at 45 Rc. Specimen at 56 Rc was essentially fully hardened, and the one at 45 Rc was not tempered.
(c) Specimens tempered to and tested at 35 Rc. Specimen at 56 Rc was essentially fully hardened, and the one at 35 Rc was not tempered.

Fig. 8.—Tensile properties of AISI 9440 steel slack-quenched to indicated hardness levels. Austenitizing temperature 1525 F.

the specimen quenched directly to 45 Rc (not tempered) fractured prematurely before reaching the maximum load, and the true values may be somewhat greater than indicated.

The tensile properties of specimens slack-quenched to different hardness levels and then tempered to 35 Rc are shown in Fig. 8 (c). At this hardness level, the tensile strength was a maximum in the "as slack-quenched" (not tempered) condition, and decreased with decreasing amounts of slack-quenched structure. However, the yield strength, reduction of area, and elongation increased with decreasing amounts of slack-quenched structure. At 35 Rc, there was a pronounced difference in properties between the specimen slack-quenched to this hardness and the specimen initially slack-quenched to 39 Rc and tempered to 35

Rc. Above 39 Rc, the differences between all tempered specimens were relatively small.

Summary

An apparatus and technique for producing any desired slack-quenched structure in a cylindrical specimen of a steel of medium hardenability is described. The method is rapid, easily reproducible, and relatively inexpensive. It may be adapted to the slack quenching of tension, impact, fatigue, and other specimens. Some data are presented to show the effectiveness of the process and the influence of different degrees of slack quenching on the tensile properties of 9440 steel.

Acknowledgments:

The authors greatly appreciate the mechanical ingenuity of William Grote,

who designed and constructed the sliding shaft assembly, and the considerable help rendered by Thomas P. Royston in grinding specimens for hardness surveys.

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EJC Information Committee Forming Task Groups

NOW THAT the Society is a member of the Engineers Joint Council (see *MR&S*, March, 1961, p. 203) ASTM members and staff will be called upon to work on EJC committees and other activities. Assistant Technical Secretary Frank Speight, representing the Society on the Computation and Information Processing (CIPS) Committee, has been named chairman of the Task Group on Liaison Activities. The CIPS Committee, which was formed in January, 1961, has this charter:

"This committee shall provide coordination of activities within the engineering

societies in the fields of design and application of information processing systems or machines. To provide channels of communication between the societies for dissemination of use of new information processing systems. To provide a central source of data on information processing technology in engineering for use by member societies, other professions, and public agencies."

CIPS Chairman W. M. Carlson, E. I. du Pont de Nemours & Co., is organizing eight task groups to handle the following eight projects:

Intersociety Cooperation

1. Joint meetings
2. Liaison, internal and external

Education

3. Professional training

Techniques

4. Program documentation and interchange
5. Languages
6. Information storage and retrieval

Economics of Application

7. Standardization
8. Over-all systems cost

The main committee comprises one delegate from each EJC member society. While task groups will be headed by committee members, their members may be selected also from the member societies on a basis of interest and competence in the subject.

In-Motion Radiography of Sergeant Missile Motor Casing

By ERNEST H. RODGERS

IN-MOTION RADIOGRAPHY, while certainly not new, can be adapted to many varied radiographic problems. A method of in-motion radiography¹ has proved feasible for the inspection of longitudinal welds in the Thor missile.

Adapting the in-motion radiographic technique to the Sergeant missile motor casing was not too difficult a task as far as the longitudinal welds were concerned; however, an attempt was made to radiograph both the longitudinal and the circumferential welds with but one continuous exposure. Roughly, this would mean that 44 ft of welding could be radiographed in less than 20 min exposure time. With the use of a rod-anode tube, strip film could be used, thereby decreasing the setup time considerably. There were a few problems to be solved before the application could be proved suitable to radiography of both the circumferential and longitudinal welds with the in-motion technique. The solution of these problems is presented in this report.

Materials and Test Procedure

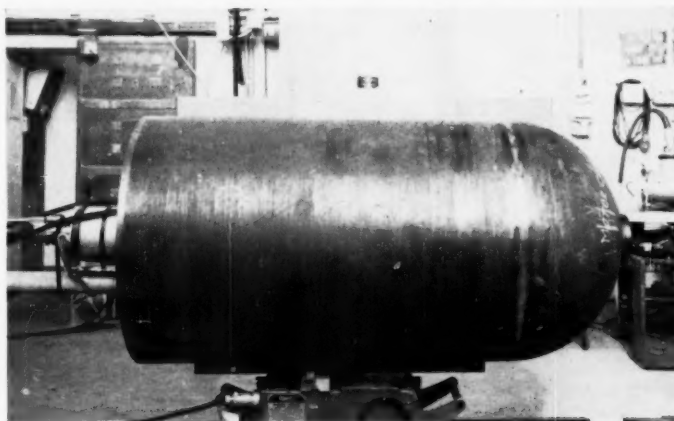
Materials

In an endeavor to prove the feasibility of applying the in-motion radiographic technique to the Sergeant missile motor casing, a short section of the missile was used. This section contained a circumferential weld approximately 98 in. around the outside diameter and a longitudinal weld 48 in. long, as shown in Fig. 1.

A 150-kv rod-anode tube, Fig. 2, is supported on a boom in a fixed position and the motor casing travels on a small variable-speed carriage which rides on metal tracks. Slow-speed strip film 70 mm wide is taped around both the circumferential and the longitudinal welds as shown in Fig. 3.

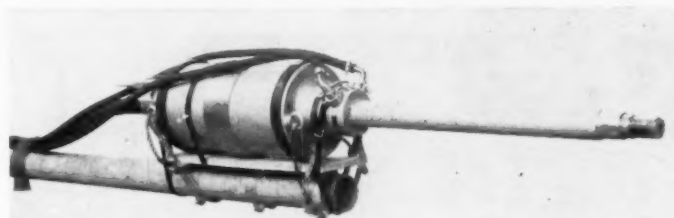
The motor casing is made from 4130 steel in accordance with Specification MIL-S-18729B, with a wall thickness of

This in-motion radiography project was undertaken in an attempt to reduce the delay time resulting from the use of conventional radiographic techniques. The successful conclusion of the project resulted in decreased setup time, decreased exposure and processing time, ease of interpretation, and considerable savings in inspection costs.



U. S. Army Photograph

Fig. 1.—Section of Sergeant missile motor casing supported by drive carriage.



U. S. Army Photograph

Fig. 2.—150/15 rod-anode tube.

0.109 in. Weld bead over-all thickness varies up to 0.200 in.

Test Procedure

The first task to be solved was the proper design of the beam-restricting device to provide the correct exposure for any predetermined speed of travel. It became immediately apparent that

for the specific purpose intended there was no suitable device available. A device which proved very suitable for the purpose was designed and constructed at Watertown Arsenal Laboratories and is shown in place on the rod-anode tube in Fig. 4. The after end of the device is merely a lead disk attached to a sleeve which slides over the outside

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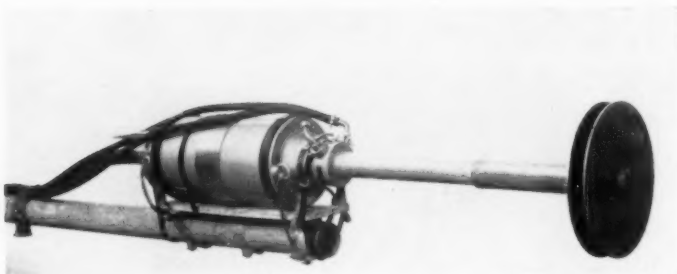
¹ W. C. Hitt and D. J. Hagemeyer, "Radiography of Weldments in Motion," Symposium on Nondestructive Testing in the Missile Industry, *ASTM STP No. 278*, Am. Soc. Testing Mats., p. 40 (1959).

ERNEST H. RODGERS, chief, Methods Evaluation Section, Nondestructive Testing Branch, Materials Testing Laboratory, Watertown Arsenal, Watertown, Mass., is Ordnance Corps Liaison Member of Committee E-7 on Nondestructive Testing. He has completed 21 years of service at Watertown Arsenal, 11 years of which have been in the field of nondestructive testing. He received the associates degree in industrial engineering and a B.B.A. in engineering and management from Northeastern University.



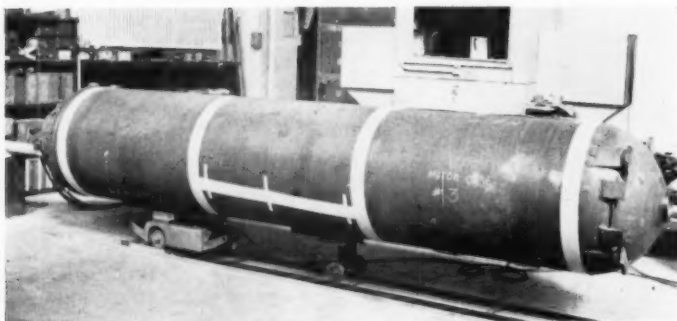
U. S. Army Photograph.

Fig. 3.—Section of Sergeant missile with film in place.



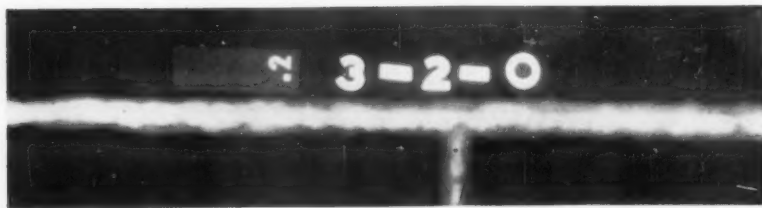
U. S. Army Photograph.

Fig. 4.—Beam-restricting device.



U. S. Army Photograph.

Fig. 5.—Drive carriage, variable speed, supporting complete missile.



U. S. Army Photograph.

Fig. 7.—Radiographic print of circumferential weld.



U. S. Army Photograph.

Fig. 6.—Beam spread at 15.5-in. focal film distance.

of the rod of the tube. This allows for greater variation of the beam restriction by merely sliding the sleeve one way or the other.

Additional variables, such as voltage, current, and speed of travel, combine to give the appropriate density required. Figure 5 shows the carriage upon which the motor casing rides. Four wheels may be placed horizontally on the carriage to permit rotation of the motor casing, thus facilitating layout and numbering of the radiographic areas as well as allowing easy access for marking out defective areas for repair.

Test Exposure Factors

Numerous trial runs were conducted at different travel speeds and voltages before the optimum factors were selected. Travel speed was an important factor, and, although a fast travel was certainly desirable for obvious economical reasons, the other variables did impose certain restrictions. A speed of 8 in. per min was finally selected. This speed permitted complete radiography of the missile casing in 20 min, exclusive of setup time.

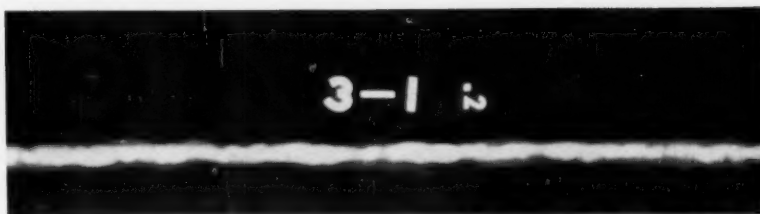
The beam-restricting devices were spaced 1 in. apart. This, of course, permitted 360 deg radiation with the 1-in. aperture. The actual beam spread measures approximately 1.5 in. at a focal film distance of 15.5 in., as shown in Fig. 6. Lead sheet $\frac{1}{8}$ in. thick is used for the beam-restricting devices, which were designed to be 10 in. in diameter. This is actually an arbitrary figure and could conceivably be larger or smaller if desired.

The maximum of 150 kv at 15 ma gave the desired density for this particular missile casing with slow-speed fine-grain film. All films were processed in liquid developer for maximum contrast at 68 F. Radiographic prints of the circumferential and longitudinal welds are shown in Figs. 7 and 8, while the entire missile casing setup is shown in Fig. 9.

A comparison was made of the image quality of radiographs produced by conventional radiography and the in-motion technique. Results showed that radiographs obtained by the in-motion technique were of equal quality and far more easily obtained. Radiographic penetrameter sensitivity of 1T is routine with the in-motion technique; however, it should be pointed out here that on the lower thickness ranges the penetrameters now in use do not show a true picture of the radiographic sensitivity on a percentage basis. The in-motion technique does give a sensitivity level at least equal to that obtained by conventional methods.

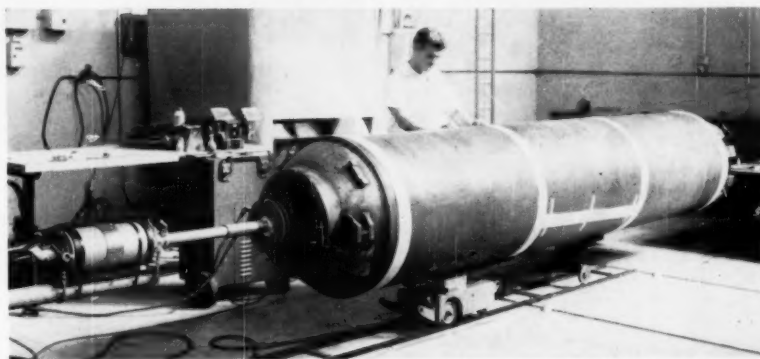
Conclusions

As a result of this investigation, the



U. S. Army Photograph.

Fig. 8.—Radiographic print of longitudinal weld.



U. S. Army Photograph

Fig. 9.—Entire missile casing setup for radiography.

time now saved by using a rod-anode tube, strip film, and the in-motion technique for both longitudinal and circumferential weld radiography is outstanding. No exact comparison of the conventional method and the in-motion technique can be made, owing to the many and varied techniques at different installations; however, at this installation, complete radiography of the first missile casing using conventional methods required approximately 60 man-

hours, while the in-motion technique required less than 4 man-hours. The actual down-time for inspection has been reduced, permitting increased production.

Exposure time for radiography of the entire motor case has been cut down to 20 min and is accomplished by only one single exposure. The conventional method required 44 single exposures of 2-min duration each, exclusive of long setup time.

Pressure-Differential Testing of Tubing

By G. H. SYMONS

IN RECENT years the trend in tubing has been to lighter walls, both in seamless plain-surface and finned tubing. Small metallurgical or mechanical imperfections in such tubing increase the likelihood of small leaks. The use of eddy-current type of non-destructive testing has virtually eliminated the quality problem in seamless plain-surface tubing. Irregular surfaces on extended fin tubing and the odd shapes of many fabricated tubular parts, however, usually rule out the use of such electronic equipment. The most common method used for such parts is

Tubes or tubular products often must be tested for pressure tightness. The common test methods use a liquid such as water. In certain applications, however, the presence of water is undesirable. This paper proposes a test method in which the soundness of a vessel is determined by its ability to maintain a given air pressure.

Two of the units to be tested are charged with identical air pressure, isolated from the air supply and from each other, and interconnected through a U-tube manometer. After a suitable waiting period, the manometer is observed to determine whether or not a pressure differential exists between the two units.

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to subject them to an air-under-water test.

In the conventional air-under-water test, the tube is subjected to internal air pressure, generally 250 psi, and immersed in water. Leaks are detected as air bubbles escaping from the tube. While this test normally detects leaking tubes, it has some undesirable aspects. It wets the tube, which, in turn, may cause staining or require subsequent drying. The entire tube must be observed for leaks; therefore large tanks are often required. The entire operation is often messy.

From numerous field reports it became apparent that failures due to leaking tubes in freon service were due to extremely small leaks that required more than the usual 5-sec air-under-water test to detect. Minute leaks that were detected under pressure after assembly into units revealed that either a more sensitive test had to be developed or excessively long test cycles (up to 5 min) were necessary to give customer quality assurance.

With the introduction of extremely rigid cleanliness requirements for atomic energy applications, the need for a clean, water-stain-free tube accelerated the development program for a technique that did not use water as a testing medium.

A commonly used method for determining the soundness of vessels is to subject them to a pressure or vacuum for a period of time. A pressure differential test was developed in an attempt to eliminate the undesirable features of the air-under-water test.

Development

The basic steps in this test method are to: charge the parts to be tested with air pressure, wait for a period of time, and then determine whether a loss in pressure has occurred.

Such a method did not prove to be satisfactory for the following reasons: Expansion or contraction of the air made it difficult to detect faulty tubes, gages of adequate sensitivity were not available, and the length of time required for the test was excessive.

In order to eliminate these undesirable features, the method of comparing two identical units bridged by a manometer was evolved.

Principle

In the pressure-differential test air under pressure is simultaneously applied to two units under test. The pressurized units are then isolated from the pressure supply, and, after a period of time, the pressure in one unit is compared to the pressure in the other unit by means of a U-tube manometer connected between the two units (Fig. 1). Any difference in pressure due to

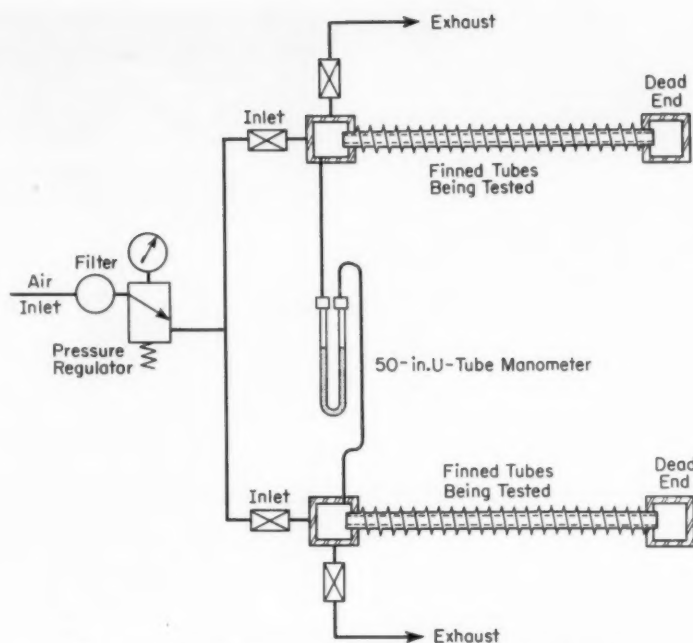


Fig. 1.—Schematic diagram of pressure-differential test system.

a leak in either unit is readily detected by the relative positions of the manometer columns. The test units may be either individual tubes or sets of tubes.

During the test, as long as the pressure on each leg of the manometer remains equal, the level of the manometer fluid in each leg will be the same. In the event of a leak in one of the units under test, the pressure on that side of the manometer will drop and the difference in pressure between the two units will cause a shift of the indicating fluid toward the low-pressure side.

Our standard has been based upon detecting a difference in levels of 0.1 in. on the manometer. This is equivalent to a pressure difference of 0.0036 psi. The time of the test is adjusted to produce this minimum 0.1-in. differential when the leak rate is 2 cu cm of air per min.

The formula for determining the time to develop a given differential is as follows (the derivation of this formula may be found in the Appendix):

$$t = \frac{M_0}{L} - \left(\frac{\left[P_0 \left(\frac{1}{1 + \left(\frac{0.5 h A}{V_0} \right)} \right)^K \right] - h d}{L R T_0 (V_0)^{K-1}} \right) \left[V_0 - 0.5 h A \right]^K \quad (1)$$

where:

- t = time to develop a given differential on the manometer, sec,
- L = leak rate, lb per sec (considered constant),
- M_0 = initial weight of air contained in the leaking system; M_0/L is valid only

as long as L is constant, which requires that $P_{ATM}/P_A < 0.53$, the critical ratio for air,

P_{ATM} = atmospheric or ambient pressure (say 14.696 psia),

P_A = resultant pressure after leaking for a period of time,

P_0 = starting pressure, equal in both systems (say 264.696 psia),

V_0 = volume of the system under test when differential = 0,

T_0 = temperature (deg Rankine) of system at start (say 529.69 R),

R = universal gas constant (say 639.91 in. per deg Rankine),

h = height of differential, in. (say 0.10-in. desired min),

A = cross-sectional area of manometer tube, sq in.,

d = density of manometer fluid, lb per cu in., and

K = ratio of specific heats of confined gas, $C_p/C_v = 1.405$ for air.

Operational Procedure

The straight-length tubes to be tested are inserted into a fixture which has

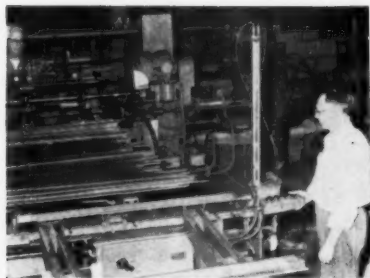


Fig. 2.—View of a four-tube tester.

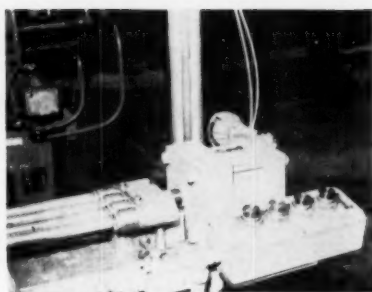


Fig. 3.—Close-up view showing charging-end head and manometer.

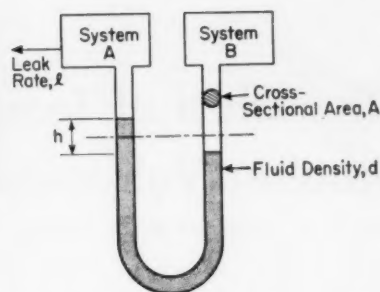


Fig. 4.—Schematic diagram of manometer system.

heads to clamp and seal both ends (Fig. 2). On each tube, one of these heads "dead-ends" the tube while the inlet, exhaust, and manometer connections are incorporated into the other head (Fig. 3). Once the tubes are clamped into position, a switch starts the cycle into operation. The tubes are charged with air until they reach a pressure of 250 psi; the air-operated inlet valves close and the tubes are under test for the required time, then the air-operated exhaust valves open and the test cycle is complete. The entire cycle is controlled by a timer and is automatic once it is started.

During the test period, the operator observes the manometer columns for an indication of a differential pressure between the two units under test. It is imperative that the comparison be made between two identical units so that all factors other than leaks will be cancelled.

The U-tube manometer used is a 50-in. model equipped with vent checks to prevent sudden surges in pressure from blowing out the indicating fluid. The fluid used has a specific gravity of 0.824.

Discussion

In order for this test method to be successful, it is imperative that the equipment be absolutely pressure-tight. When such a condition is not met, it could result in the rejection of sound tubes.

It is theoretically possible that, two identical leaks could be encountered on opposite sides of the manometer simultaneously and, therefore, not be detected. The number of leaking tubes being encountered will greatly influence the possibility of such a situation. If the frequency of defective tubes is normally one in a thousand (a reasonable number, based on experience), then the probability of two defective tubes occurring in the same test set (the product of the individual probabilities) is one in a million. Further, the probability of the leaks being of the same magnitude increases to a point of astronomical odds.

Advantages

The advantages of this test method are as follows:

1. It eliminates the necessity of a liquid, thus permitting the tube or parts to remain clean and dry.

2. It has greater accuracy than conventional methods of testing. The time under test is such that all leaks which would normally be detected in an air-under-water test will be apparent by this method. Greater accuracy may be obtained by simply increasing the time under test.

3. It is "fail safe" in that malfunction of the equipment would not pass defective tubes, although it might reject sound tubes.

4. It reduces operator fatigue because he need only observe the manometer instead of the entire part being tested. He is not faced with such decisions as whether a bubble adhering to the tube surface is the result of a minute leak or merely entrapped air. In the case of long lengths or intricate shapes, less manpower is required.

5. It is adaptable to automation by use of suitable automatic loading and unloading equipment and sensing devices.

APPENDIX

Assume two systems, A and B, of equal initial volume V_0 , mass M_0 , temperature T_0 , and pressure P_0 . If system A leaks at a constant rate l , then the relationship between the time t , the leak rate, and the differential h developed may be derived as follows:

SYSTEM A

$$P_A + hd = P_B$$

$$V_A = V_0 - \frac{1}{2}hA$$

$$T_A = T_0 \left(\frac{V_0}{V_0 - \frac{1}{2}hA} \right)^{\kappa-1}$$

$$M_A = M_0 - Lt$$

SYSTEM B

$$P_B = P_0 \left(\frac{V_0}{V_0 + \frac{1}{2}hA} \right)^{\kappa}$$

$$V_B = V_0 + \frac{1}{2}hA$$

$$T_B = T_0 \left(\frac{V_0}{V_0 + \frac{1}{2}hA} \right)^{\kappa-1}$$

$$M_B = M_0$$

The general relationship would be:

$$P_A V_A = (M_0 - Lt) R T_A$$

$$P_B V_B = M_0 R T_B$$

$$M_0 - Lt = \frac{P_A V_A}{R T_A}$$

$$t = \frac{M_0}{L} - \frac{P_A V_A}{L R T_A}$$

Then by substitution:

$$= \frac{M_0}{L} - \left(\frac{\left[P_0 \left(\frac{1}{1 + \left(\frac{0.5 h A}{V_0} \right)} \right)^{\kappa} - h d \right] \left[V_0 - 0.5 h A \right]^{\kappa}}{L R T_0 (V_0)^{\kappa-1}} \right)$$

The Effect of Temperature on the Air Aging of Rubber Vulcanizates

By A. E. JUVE and M. G. SCHOCH, JR.

IN TWO previous publications of the same title^{1,2} we have reported the results of accelerated and shelf aging tests on a series of natural and synthetic rubber vulcanizates. In the first of these¹ only short-term shelf aging results were reported, but all the higher temperature aging data were included. In the second,² which attempted to answer the question that prompted the studies, the shelf aging data extended up to 4 yr. Since then additional and final data have become available including 8- and 12-yr periods for test A (the program initiated by a task group reporting to Subcommittee XV on Life Tests for Rubber Products of ASTM Committee D-11 on Rubber and Rubber-like Materials) and 2720-day (7.45-yr) data for test B (the program initiated by a committee on high-temperature aging reporting to Subcommittee IV on Classification and Specifications of Automotive Rubber Compounds of the joint SAE-ASTM Committee on Automotive Rubber).

It was thought desirable to report these additional data, because the changes in properties resulting from shelf aging are now more sharply delineated than at the time of the last report, and because data of this kind, particularly on the synthetic rubbers, are not readily available.

Results and Discussion

For convenience all the shelf aging data for both tests A and B are given in in Tables I and II along with the percentage of each property retained for each aging period. The new data are the 8- and 12-yr data in Table I and the 2720-day data in Table II.

The data in terms of percentage of each property retained were plotted versus log time, as before, and these curves are shown in Figs. 1 to 4 (The

curves for the short cure times for the compounds of Test A are not shown.) It was mentioned in the previous paper² that the results of the room-temperature aging were more erratic than those for the high-temperature aging and that this was due, in part at least, to the long intervals between the former tests. In most cases there can be no doubt as to the course of the curves, but in other cases considerable liberty was exercised in drawing the curves. In a few instances, indicated by question marks in Tables I and II, it appeared that a gross error had been made in testing. In all cases these curves were compared with the curves for the higher temperature tests, as was done in Figs. 1 to 15 of the previous report,² and the temperature

dependence of the deterioration was rechecked. In no case were the times for equal degrees of deterioration changed by any substantial time over those shown in those figures. In the process of making these comparisons it was discovered that mistakes had been made in five of the fifteen figures of the last report (Figs. 3, 4, 13, 14, and 15)² in that, contrary to the legend on the curves, the dotted curves represent elongation while the solid curves represent tensile strength.

In both test A and test B two conditions of shelf aging were employed. In test A the aging in this country was at an ambient temperature of 77 F. In Liberia the average aging temperature was reported to be 85 F, and it has been assumed that this temperature difference

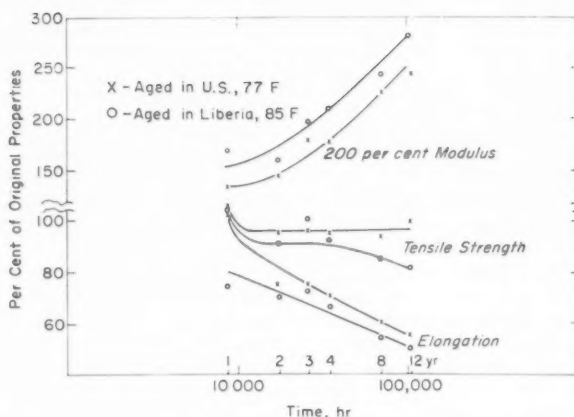


Fig. 1.—Results of test A, Compound No. 1, SBR tread type, 90-min cure at 275 F.

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¹ M. G. Schoch, Jr., and A. E. Juve, "Effect of Temperature on Air Aging of Rubber Vulcanizates," Symposium on Aging of Rubber, ASTM STP No. 89, Am. Soc. Testing Mats., p. 59 (1959).

² A. E. Juve and M. G. Schoch, Jr., "The Effect of Temperature on the Air Aging of Rubber Vulcanizates," ASTM BULLETIN, No. 195, p. 54, Jan., 1954.

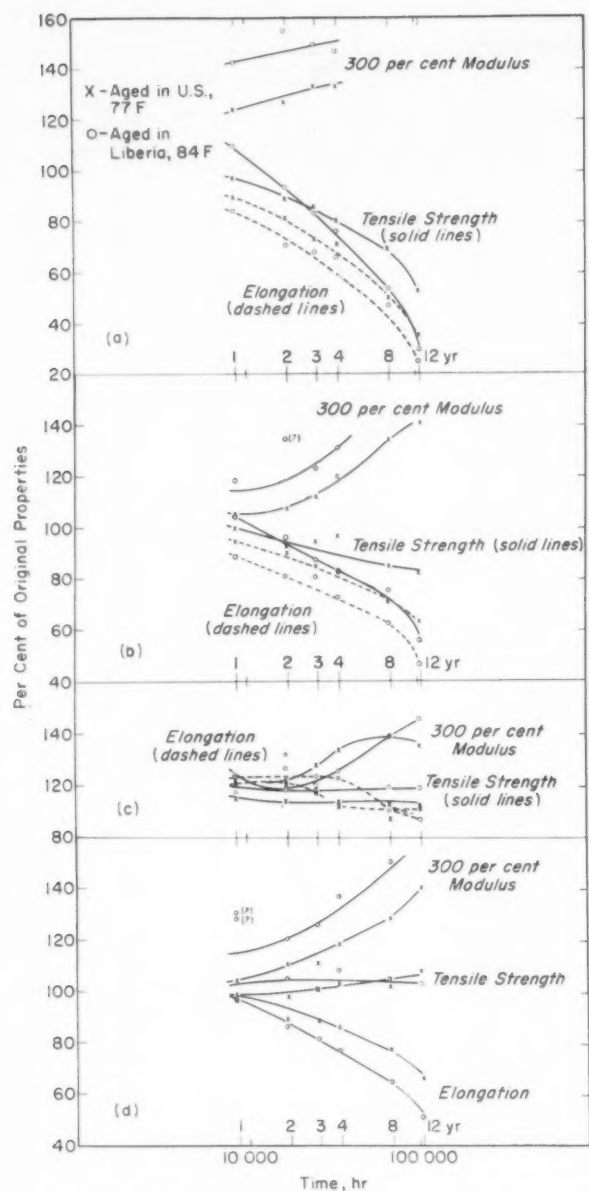
A. E. JUVE, a past-director of ASTM, has been concerned with various aspects of the technology of rubbers for the past 35 years. He has been active in Committee D-11 on Rubber and Rubber-Like Materials and is currently chairman of Subcommittee XXIX on Compounding Materials. He has published numerous papers in the field of rubber technology. His present position is director of technical services research for the B. F. Goodrich Co. at its research center in Brecksville, Ohio.

M. G. SCHOCH, JR., has been with the Hewitt Rubber Div. of Hewitt Robins, Buffalo, N. Y., for the past 20 years. He began as a hose construction technician, was a production foreman, and for the past 13 years has been manager of quality control. He has been active on subcommittees of Committee D-11 on Rubber and Rubber-Like Materials and Committee D-13 on Textile Materials.

TABLE I.—RESULTS FOR TEST A.

COMPOUND No. 1							COMPOUND No. 2					
Aging Time, yr	200 Per Cent Modulus	Per Cent Retained	Tensile Strength, psi	Per Cent Retained	Elong- ation, per cent	Per Cent Retained	300 Per Cent Modulus	Per Cent Retained	Tensile Strength, psi	Per Cent Retained	Elong- ation, per cent	Per Cent Retained
60 MIN AT 275 F CURE							45 MIN AT 275 F CURE					
Original.....	461	100	2150	100	550	100	1457	100	4070	100	615	100
1a.....	616	133.7	2249	104.5	532	96.6	1821	125	4120	101	584	95
2a.....	680	147.6	2230	103.8	475	86.4	1970	135	3809	93.5	526	85.5
3a.....	941	204.0	2190	102.0	450	81.7	1992	137	3785	93	509	82.8
4a.....	856	185.5	2333	108.5	425	77.3	1977	136	3125	76.9	482	78.3
8a.....	1079	234.0	2300	107.0	345	62.7	2260	155	2860	70.2	380	61.7
12a.....	1271	276.0	2180	101.5	300	54.5	2120	145.5	2480	61	350	56.9
1b.....	700	152.0	2500	116.3	487	88.5	2100	144	4600	113	545	88.5
2b.....	742	161.0	2008	93.5	427	77.7	2225	153	3766	92.5	466	75.6
3b.....	1000	217.0	2350	109.2	440	80.0	2150	147.2	3850	94.5	500	81.2
4b.....	900	195.0	1975	91.8	380	69.0	2175	149.5	3550	87.2	470	76.3
8b.....	1125	244.0	1975	91.8	330	60.0	1950	134	2375	57.7	380	61.8
12b.....	1462	317.0	1950	90.6	260	47.2	...	...	1400	34.4	240	39.0
90 MIN AT 275 F CURE							90 MIN AT 275 F CURE					
Original.....	588	100	2315	100	500	100	1740	100	3990	100	560	100
1a.....	782	133	2644	114.2	526	105.2	2155	123.8	3876	97	503	89.8
2a.....	843	143	2188	94.5	375	75	2200	126.3	3538	88.6	455	81.2
3a.....	1050	178.5	2210	95.4	375	75	2304	132.5	3383	84.9	405	72.2
4a.....	1033	176	2200	95.0	354	70.8	2316	133	3199	80	398	71
8a.....	1325	225	2170	93.8	300	60	...	...	2740	68.6	280	50
12a.....	1438	244	2290	99.0	275	55	...	...	2100	52.5	200	35.7
1b.....	1000	169.8	2500	108.0	370	74	2745	142	4375	109.8	470	83.8
2b.....	933	158.5	2100	90.8	350	70	2700	155	3725	93.3	393	70
3b.....	1150	195.2	2325	100.5	360	72	2600	149.5	3325	83.2	380	67.8
4b.....	1225	208.0	2125	92.0	320	64	2550	146.5	3025	75.8	370	66
8b.....	1425	242.0	1950	84.4	270	54	...	...	2125	53.3	260	46.3
12b.....	1650	280.0	1650	71.3	200	50	...	...	1175	29.4	140	25
COMPOUND No. 3							COMPOUND No. 4					
Aging Time, yr	300 Per Cent Modulus	Per Cent Retained	Tensile Strength, psi	Per Cent Retained	Elong- ation, per cent	Per Cent Retained	300 Per Cent Modulus	Per Cent Retained	Tensile Strength, psi	Per Cent Retained	Elong- ation, per cent	Per Cent Retained
45 MIN AT 290 F CURE							20 MIN AT 300 F CURE					
Original.....	1950	100	3700	100	500	100	835	100	1760	100	540	100
1a.....	2128	109	3633	98.2	476	95.2	850	102	1670	94.8	507	93.9
2a.....	2260	116	3315	89.5	440	88	830	99.4	1660	94.2	530	98
3a.....	2300	118	3413	92.3	450	90	843	101	1725	97.9	520	96.3
4a.....	2428	124.6	3507	94.7	435	87	938	112.2	1685	95.7	490	90.7
8a.....	2888	145	3236	87.3	362	72.4	932	111.7	1757	99.7	525	97.2
12a.....	2842	146 (?)	2957	79.8	310	60.2	996	119.3	1800	102.2	520	96.3
1b.....	2400	123	3850	104.1	457	91.4	775	92.8	1900	108	557	103
2b.....	2675	137	3375	91.1	387	77.4	800	95.9	1900	108	560	103.8
3b.....	2600	133.3	3050	82.4	370	74	848	101.8	1925	109.4	580	107.5
4b.....	2750	141	3225	87.1	370	74	875	104.8	1775	100.8	540	100
8b.....	...	...	2650	71.6	290	58	1050	125.7	1875	106.5	500	92.5
12b.....	...	...	2125	57.5	220	54	1125	134.8	1775	100.8	460	85.2
90 MIN AT 290 F CURE							30 MIN AT 300 F CURE					
Original.....	2142	100	3675	100	470	100	1073	100	1710	100	440	100
1a.....	2270	105.8	3666	99.8	446	94.8	1090	101.5	1615	94.3	440	100
2a.....	2307	107.5	3420	93	425	90.5	1075	100.1	1600	93.5	445	101.2
3a.....	2400	112	3470	94.3	400	85.1	1155	107.7	1700	99.3	428	97.3
4a.....	2568	120	3542	96.6	390	83	1215	113.2	1580	92.3	398	90.4
8a.....	2878	134.1	3129	85.1	335	71.2	1275	118.5	1570	91.7	380	86.3
12a.....	3017	140.4	3012	82	300	63.7	1229	114.5	1697	99	405	92
1b.....	2550	119	3850	104.8	420	89.1	1100	102.3	1750	102.2	427	97
2b.....	2900 (?)	135	3533	96.1	380	80.6	1050	97.6	1900	111.1	466	106
3b.....	2625	122.5	3200	87.0	380	80.6	1075	100.1	1675	97.8	450	102.2
4b.....	2800	130.5	3075	83.6	370	73.3	1125	104.8	1750	102.3	450	102.2
8b.....	...	...	2775	75.5	295	62.8	1275	118.5	1700	99.3	400	90.8
12b.....	...	...	2050	55.8	220	46.8	1350	125.7	1700	99.3	380	86.4
COMPOUND No. 5							COMPOUND No. 6					
Aging Time, yr	300 Per Cent Modulus	Per Cent Retained	Tensile Strength, psi	Per Cent Retained	Elong- ation, per cent	Per Cent Retained	300 Per Cent Modulus	Per Cent Retained	Tensile Strength, psi	Per Cent Retained	Elong- ation, per cent	Per Cent Retained
45 MIN AT 275 F CURE							45 MIN AT 275 F CURE					
Original.....	1547	100	2450	100	510	100	1547	100	2450	100	510	100
1a.....	1618	104.7	2516	102.6	435	85.2	1618	104.7	2516	102.6	435	85.2
2a.....	1753	113.4	2343	95.7	446	87.4	1753	113.4	2343	95.7	446	87.4
3a.....	1720	111.1	2410	98.2	450	88.2	1720	111.1	2410	98.2	450	88.2
4a.....	1980	128	2540	103.5	438	85.9	1980	128	2540	103.5	438	85.9
8a.....	2205	142.7	2445	99.9	369	72.2	2205	142.7	2445	99.9	369	72.2
12a.....	2450	158.4	2675	109	325	63.6	2450	158.4	2675	109	325	63.6
1b.....	1925	124.5	3125 (?)	127.7	480	94	1925	124.5	3125 (?)	127.7	480	94
2b.....	1950	126.2	2510	102.4	420	82.2	1950	126.2	2510	102.4	420	82.2
3b.....	2050	132.6	2525	103.2	430	84.1	2050	132.6	2525	103.2	430	84.1
4b.....	2125	137.7	2450	100	380	74.5	2125	137.7	2450	100	380	74.5
8b.....	2537	164	2600	106	310	60.7	2537	164	2600	106	310	60.7
12b.....	...	...	2625	107.2	280	54.8	...	...	2625	107.2	280	54.8
90 MIN AT 275 F CURE							90 MIN AT 275 F CURE					
Original.....	1745	100	2500	100	465	100	1745	100	2500	100	465	100
1a.....	1816	104	2487	99.5	450	96.7	1816	104	2487	99.5	450	96.7
2a.....	1943	111.2	2450	98	417	89.6	1943	111.2	2450	98	417	89.6
3a.....	1950	112	2540	101.6	410	88.1	1950	112	2540	101.6	410	88.1
4a.....	2080	119.2	2580	103.1	400	86	2080	119.2	2580	103.1	400	86
8a.....	2255	129	2545	102	362	77.8	2255	129	2545	102	362	77.8
12a.....	2460	141	2700	108	310	66.6	2460	141	2700	108	310	66.6
1b.....	2275	130.2	3210 (?)	128.5	453	97.3	2275	130.2	3210 (?)	128.5	453	97.3
2b.....	2100	120.2	2625	105	400	86	2100	120.2	2625	105	400	86
3b.....	2200	126	2525	101	380	81.6	2200	126	2525	101	380	81.6
4b.....	2400	137.5	2725	109	360	77.3	2400	137.5	2725	109	360	77.3
8b.....	2625	150.5	2625	105	300	64.4	2625	150.5	2625	105	300	64.4
12b.....	...	...	2575	103	240	51.6	...	...	2575	103	240	51.6

a United States. b Liberia.



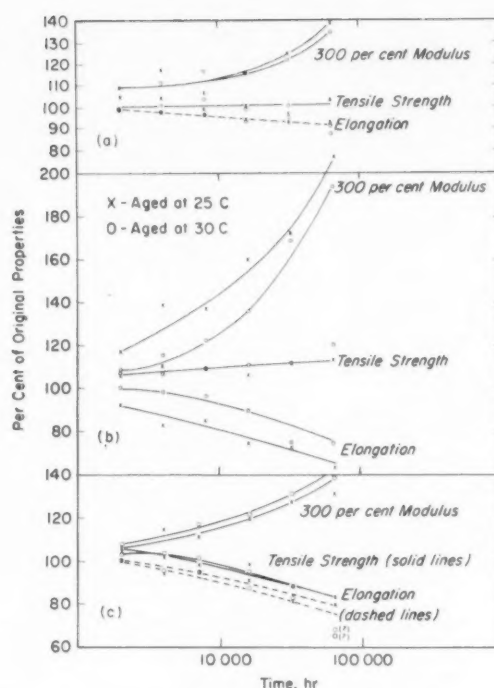
(a) Compound No. 2, natural rubber tread type, 90-min cure at 275 F.
 (b) Compound No. 3, neoprene stock, 90-min cure at 290 F.
 (c) Compound No. 4, IIR stock, 30-min cure at 300 F.
 (d) Compound No. 5, nitrile rubber stock, 90-min cure at 275 F.

Fig. 2.—Results of Test A.

was the only difference affecting the course of the deterioration. That this is very likely the case is indicated by the fact that the points for equal degrees of deterioration on the Arrhenius-type plots fall fairly consistently on a straight line.

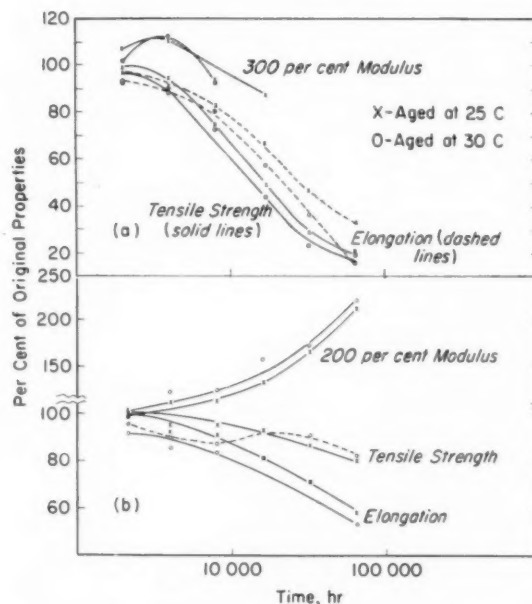
In test B the aging temperatures were 25 and 30 C. In this case two of the five compounds, No. 1 and No. 2, showed faster deterioration at the lower temperature than at the higher. The other three compounds behaved as one

would expect. Since three compounds did behave as expected it is unlikely that the exposure temperatures were not as reported. The exposures at 25C were conducted in a closed cabinet through which air was circulated and in which all the specimens were hung to-



(a) Compound No. 1, natural rubber, TMTD cure.
 (b) Compound No. 2, nitrile rubber, TMTD cure.
 (c) Compound No. 3, natural rubber tread type.

Fig. 3.—Results of Test B.



(a) Compound No. 4, natural rubber tread type without age resistor.
 (b) Compound No. 5, SBR tread type.

Fig. 4.—Results of Test B.

gether. It is likely that some interaction between compounds was responsible. It is of interest to note that the two compounds involved were both cured with tetramethylthiuramdisulfide (TMTD) and may have been more susceptible to an interaction effect

TABLE II.—RESULTS FOR TEST B.

Compound No. 1							Compound No. 2					
Aging Time, days	300 Per Cent Modulus	Per Cent Retained	Tensile Strength, psi	Per Cent Retained	Elongation, per cent	Per Cent Retained	300 Per Cent Modulus	Per Cent Retained	Tensile Strength, psi	Per Cent Retained	Elongation, per cent	Per Cent Retained
Original	680	100	2508	100	602	100	872	100	2244	100	669	100
85 (at 25 C)	740	109	2637	105	600	99.6	1027	117.6	2380	106	617	92.2
170 (at 25 C)	798	117.4	2614	104	588	97.8	1208	138.3	2488	110.8	555	83
340 (at 25 C)	723	106.3	2498	99.5	578	96.1	1200	137.6	2460	109.5	570	85.2
680 (at 25 C)	788	116	2516	100.1	566	94	1397	160	2390	106.2	495	74.1
1360 (at 25 C)	852	125.2	2438	97	557	92.5	1503	172.5	2526	112.5	489	73.1
2720 (at 25 C)	940	138.2	2580	103	560	93	1850	212	2550	113.4	425	63.5
85 (at 30 C)	670	98.5	2492	99.3	590	98	863	99	2318	108	670	100
170 (at 30 C)	758	111.7	2523	100.6	592	98.3	1008	115.5	2400	106.7	656	98
340 (at 30 C)	793	116.8	2597	103.5	580	96.5	1062	122	2454	109.2	644	96.2
680 (at 30 C)	787	115.8	2474	98.5	560	93.2	1186	136	2484	110.7	594	88.8
1360 (at 30 C)	828	121.9	2520	100.3	572	95	1474	169	2510	111.8	500	74.8
2720 (at 30 C)	915	134.7	2265 (?)	90.3	525 (?)	87.1	1690	194	2700	120	500	74.8

Compound No. 3							Compound No. 4					
Aging Time, days	300 Per Cent Modulus	Per Cent Retained	Tensile Strength, psi	Per Cent Retained	Elongation, per cent	Per Cent Retained	300 Per Cent Modulus	Per Cent Retained	Tensile Strength, psi	Per Cent Retained	Elongation, per cent	Per Cent Retained
Original	1547	100	3838	100	569	100	1887	100	3485	100	490	100
85 (at 25 C)	1640	106	4004	104.5	569	100	2018	107	3452	99	475	97
170 (at 25 C)	1770	114.5	3882	101.3	532	93.3	2088	111	3317	95	448	91.5
340 (at 25 C)	1712	111	3760	98	538	94.5	1777	94	2590	74.3	408	82.4
680 (at 25 C)	1855	120	3773	98.4	515	90.4	1652	87.5	1723	49.5	322	66.6
1360 (at 25 C)	1960	127	3378	88	462	81.1	...	...	1030	29.5	231	47.1
2720 (at 25 C)	2035	131.7	3210	82.7	460	80.8	...	...	720	20.6	165	33.6
85 (at 30 C)	1666	107.7	3952	103	572	100.2	1920	101.8	3232	92.5	458	93.5
170 (at 30 C)	1780	115	3963	103.1	545	95.8	2115	112	3120	89.5	432	88.2
340 (at 30 C)	1810	117	3890	101.5	540	95	1753	92.7	2542	73	394	80.3
680 (at 30 C)	1883	121.7	3625	94.5	500	87.8	...	...	1525	43.7	282	57.5
1360 (at 30 C)	2023	131	3378	88	472	84.9	...	...	820	23.5	177	36.1
2720 (at 30 C)	2140	138.5	2595 (?)	67.6	370 (?)	64.9	...	...	695	19.9	80	16.3

Compound No. 5						
Aging Time, days	200 Per Cent Modulus	Per Cent Retained	Tensile Strength, psi	Per Cent Retained	Elongation, per cent	Per Cent Retained
Original	862	100	3496	100	491	100
85 (at 25 C)	858	99.5	3660	104.9	495	101
170 (at 25 C)	972	113	3343	95.7	453	92.3
340 (at 25 C)	986	114.5	3357	96	450	91.5
680 (at 25 C)	1155	134	3276	93.5	396	80.7
1360 (at 25 C)	1438	166.8	3026	86.5	347	70.7
2720 (at 25 C)	1850	214.5	2820	80.7	285	58
85 (at 30 C)	855	99.2	3342	95.5	450	91.5
170 (at 30 C)	1053	122.2	3137	89.5	420	85.5
340 (at 30 C)	1075	124.9	3066	87.7	410	83.5
680 (at 30 C)	1360	157.7	3246	92.8	400	81.4
1360 (at 30 C)	1498	173.5	3190	91.3	350	71.2
2720 (at 30 C)	1910	221	2870	82.1	270	55

than the other three compounds. It is also of interest to mention that compound No. 2, which shows the greatest difference between aging at 25 C and at 30 C, was the same compound that was reported previously¹ to have given erratic results after oven aging at 70 and 100 C. This compound was the subject of a further investigation³ which showed a very marked interaction effect when aged in close proximity to a normal sulfur-cured stock.

These additional data on room-temperature aging have not changed the conclusions drawn in the previous report. For the convenience of the reader those conclusions are repeated here and represent our final summary of these projects.

Summary

1. The changes that occur on the air aging of vulcanizates of GR-S, nitrile rubbers, and neoprenes over the temperature range of room temperature to 150 C appear to be essentially the same

at all temperatures, the rate of change depending on the temperature in a regular way. The apparent activation energies calculated from the available data are $19,000 \pm 2000$ cal per mole.

2. For natural rubber stocks the temperature range over which similar deterioration occurs is narrower and is limited by: (a) the appearance of nonhomogeneous deterioration caused by a rate of reaction of oxygen with the rubber too rapid to permit uniform diffusion of oxygen throughout the cross-section of the specimen, and (b) a change in the balance between chain scission and cross linking as the aging temperature is increased, the higher temperatures favoring chain scission. The apparent activation energies for three of the four natural rubber stocks are in the range of 20,000 to 25,000 cal per mole. The fourth natural rubber stock that vulcanized with TMTD, exhibits a steady increase in chain scission with increasing temperature of exposure above 70 C making the calculated value of 28,450 cal per mole of doubtful value.

3. The GR-I stock of test A behaved differently at all test tempera-

tures, making it impossible to calculate an activation energy.

4. The ability to extrapolate the results of accelerated aging tests to higher or lower temperatures depends on: (a) whether the accelerated test temperature and the desired extrapolated temperature are in the range over which essentially the same deteriorating mechanisms prevail, and (b) a knowledge of the temperature dependence of the rate-limiting reaction.

For the synthetics, excluding GR-I, the temperature range is quite wide, extending in most cases to at least 125 C, and the activation energies are in the range of $19,000 \pm 2000$ cal per mole.

For the natural rubber stocks the temperature range is narrower, extending to about 100 C for reasonably good aging stocks. The activation energies are in the range of 20,000 to 25,000 cal per mole.

In the absence of reliable data on a particular material, aging tests should be run at two or more temperatures, preferably in the low-temperature region, to establish a basis for extrapolation.

³ A. E. Juve and Ross Shearer, "Migration Effects in Oven Aging," *India Rubber World*, Vol. 128, No. 5, pp. 623-625, Aug., 1953.

Testing Carboloy—Some Early Experiences

By S. L. HOYT

UPON RETURNING from Germany in 1925 to my work at the Research Laboratory at General Electric Co. in Schenectady I was filled with enthusiasm to develop and apply the new cemented tungsten carbide which I had seen at the Osram Lamp Works in Berlin. There was much to be learned, I soon discovered, and there followed an intensive investigation of recognizable variables before I was ready to try out tools in the Schenectady shops. Incidentally, it was from my notes of that period that the name "Carboloy" evolved as a natural contraction of "carbide alloy." It was eventually adopted officially by the General Electric Co.

During the preliminary stages the quality tests that I used were very crude. A soft Woolworth peening hammer for testing the strength of a tool bit and an examination of a fracture served valiantly and remained in use even after more refined tests were developed. I knew I needed to have material with a very fine-grain fracture and that a Carboloy bit must withstand a blow of certain though indescribable strength before qualifying for cutting tests. I also gained information from grinding and dressing tools. My attempts to supplement these tests by getting Rockwell hardness, C-scale values were stopped by the guardian of the treasury at the Research Laboratory, who told me I broke too many diamond brales.

The final test, as always, was a cutting test, and we soon had a fairly good idea of how efficient a tool had to be before we could sell it to the G.E. shops at \$1 per g. That price was not a very scientific test, but "local sales" did give a substantial appraisal of tool quality. The people in the shops grumbled, of course, but they soon

became committed and continued to use our tools.

All these tests served a useful purpose but we needed earlier and more quantitative tests for the control of carbide production and of finished Carboloy parts. We wanted to assure ourselves that both quality and uniformity, or reliability, were adequate for their use in production. In fact, we were obliged to because we were revolutionizing shop practice and upon upsetting piece rates we had to supply the shops with reliable tools day in and day out.

An early attempt to sell carbide tools (not mine) met an insurmountable handicap of a very considerable variation in quality or performance. One shop found only one piece out of 20 (of foreign manufacture) to be of suitable quality, and it was years before it enjoyed the splendid performance of a properly made product. Truly there was a great need for adequate tests and reliable specifications.

Upon passing to the final tests by means of which we mastered this situation, let it be said that, as a metallurgist, I sorely missed the information that can be obtained by microscopic examinations. That problem was accordingly put on the agenda and was ultimately handled satisfactorily.

Hardness Testing

My early work had pointed to hardness and strength as two critically important properties, so it was in order to try to develop suitable tests. I did not take kindly to the directive not to take Rockwell hardness meas-

urements, so I simply took off the weights on the Rockwell machine. Then I found I could run hardness tests with little more than mild grumblings from the front office.

At about that time, L. L. Wyman, then at the Harrison Lamp Works, began working with me on Carboloy dies for drawing tungsten wire. He proposed Rockwell A scale as the name for the new scale which I had developed for cold-pressed Carboloy of various cobalt contents and for hot-pressed Carboloy of exceptionally high hardness. I had called it the "no load" scale, but the Wilson people informed us that my "no load" scale was not constant and that they would make it a uniform 60 kg. It has remained at that value.

I had been working with Meyer's analysis of the ball hardness test, and as soon as I discovered that the Rockwell brale had a spherical end I used the mean pressure in kilograms per square millimeter as a measure of the hardness. With that technique I determined that the "no load" for my Rockwell A scale was 64 kg. Those readings were then readily converted into Rockwell A readings for new instruments with the 60-kg load.

The Rockwell A scale is foreshortened as compared to the C scale and may not give as precise a differentiation as may sometimes be desired. This situation can be improved by accurately determining the diameter of the spherical impression and calculating the mean pressure in kilograms per square milli-

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meter. On this scale I obtained hardness values as high as 2400 for hot-pressed Carboloy. This method of hardness testing gave a more realistic and useful comparison of Carboloy of various grades and with tool steels. The latter measured only about half as hard. In that respect it is valuable in research though not so well adapted to production control.

Strength Testing

Coming to determinations of the strength of Carboloy, it is to be borne in mind that a decidedly brittle material places certain limitations on the suitable methods. It was not practical to determine either the tensile strength or the compressive strength, but a simple flexure test appeared to have the necessary qualifications. I had a mold for use in studies of tungsten which gave a compact $\frac{1}{4}$ -in. square 2-in. long, and that was used for Carboloy strength tests. The test gave the flexure strength, or modulus of rupture. It then became a matter of experience to set limits for acceptable Carboloy of various cobalt contents for both hardness and strength.

The flexure test also provides a fracture surface for examination and also enabled measurements to be made of shrinkage during sintering. We used it first at the Research Laboratory for controlling local production and, later, the Carboloy Co. used it when it established commercial production at the Cleveland Wire Div. Before a lot was released, A. E. Focke would bring the test bars to Schenectady for test. Since then, other firms have found it and the hardness test to be useful.

I do not believe it has ever been published, but the best combination of strength and hardness of which I am aware was obtained when I quenched a hot-pressed test bar in water.

I have noted that Carboloy is brittle. At no time in any of our many tests did we observe evidence of ductility. This was likewise true of some special torsion tests which J. V. Emmons ran for me at Cleveland Twist Drill. Oddly enough, to me, it has been recently reported that Carboloy has appreciable and measurable ductility.¹ How this can be true with cobalt contents in the range that is used for tools and dies is a mystery and needs an explanation. The cement phase is so thin, even at 13 per cent cobalt content, that it would not be expected to confer ductility on the mass. I have accounted for the strength and hardness

of Carboloy on the basis that the cement functions solely as a cement.

Metallographic Examination

Mechanical properties are all-important, but being accustomed to using metallographic technique in work on metals, I was frustrated not to be able to examine Carboloy microscopically. The best lapping material which I had for the first year or so was boron carbide, which I got from A. L. Merrick of our electric furnace department. It was very good down to a certain point, but I could never get a metallographic polish. Then one day when at the West Lynn plant I observed the polishing of sapphire meter bearings with diamond dust. I arranged to get samples of their various grades and also requested some of their very finest powder. The latter was recovered from the olive oil that was ordinarily discarded and was well under $1\ \mu$ in diameter.

Success then came quickly. After fine grinding with boron carbide, the final polishing was done easily and cheaply, the latter in spite of the high cost of the powder. This procedure was subsequently published and was very similar to the method which a German worker published at about the same time.

For some unknown reason photographing an etched specimen was much less likely to give an acceptable photomicrograph than with steel or a common alloy. However, in my Institute of Metals Lecture of 1930, I believe I demonstrated that excellent results can be obtained, as many others have done since then.

This metallographic technique made it possible to follow particle-size distribution from the tungsten powder through tungsten carbide powder and the finished Carboloy. When correlated with tool or die performance, this brought out the desirability of starting with fine-grain tungsten and tungsten carbide powder and keeping a fine grain size through sintering. The distribution of particle size was also found to be important and was closely followed. My very best tool of that period was made with a fine-grain tungsten carbide which I made by gas carburizing tungsten powder at a low temperature. Gas carburizing was not practical and was not introduced in production.

A special grade of Carboloy was being worked on in the Research Laboratory whose unpredictable behavior was explained by the new metallographic technique. Some of the tools gave good results but others broke badly and unexpectedly during use. When I examined such a tool microscopically I learned that enormous grains had formed which lowered the

strength substantially. That could not be overcome and the grade had to be discontinued.

Hot-Pressed Carboloy

I have mentioned hot-pressed Carboloy, so perhaps a brief account of it is in order and especially so because very little was published about it at the time. I was aware of porosity in the cold-pressed Carboloy and decided to improve that situation. One time, for example, I tried to make trimmer blades for Edison Dictaphone records to prepare them for a new run. Cold-pressed Carboloy would not give a smooth cut, because the cutting edge of the blade was never free from porosity. There was no such difficulty with hot-pressed Carboloy.

The desire to improve the cold-pressed and sintered material led to the process of pressing the tungsten carbide and cobalt powders at a high temperature. Porosity was eliminated while both hardness and strength, in relation to the hardness, were improved and the product was extremely fine grained.

Upon trying to secure a patent, and though I did get the basic patent on hot-pressed Carboloy and similar materials, I learned I was not the first to use a hot-press method. To my chagrin I learned that an English patent had been issued on hot-pressing ceramics. I had used the method on porcelain, but I could not get sufficient scope to my patent to cover all hot pressing. During visits to Europe I have learned that the method is in wide use, though in the United States it is used only for special applications.

Summary

This early experience in testing Carboloy applied the guiding principles of the ASTM for similar work. First came the selection of tests which related to the essential properties, after which the details of the test methods were devised. Having suitable tests, the next step was to establish specifications for the acceptance or rejection of production lots. Neither processing nor process control was included; we relied on tests of the product. Our experience had shown that the material had to be made and processed correctly or it would not meet the specifications.

That did not mean that tools of different compositions and processed in different ways would all perform the same even though they all had essentially the same properties. The tantalum carbide tools, for example, which F. C. Kelley worked on at the Research Laboratory had about the same properties as the tungsten carbide tools, yet they were superior for some applications. We knew that the mechanical properties were important, but we recog-

¹ Betty M. Caugherty, H. T. Oatman, and O. W. Reen, "A Cooperative Study of the Hardness Testing of Cemented Carbides," *Proceedings, Am. Soc. Testing Mats.*, Vol. 59 p. 1261; Disc., p. 1275 1959.

nized that other properties or characteristics were also important. Thus our philosophy was to determine which grade was best suited to a given application and to determine its properties

when properly made for the application and then to set up appropriate specifications.

I have observed recently in Europe

and the United States that those early tests are still used, and it is hoped that this historical account may be of interest to those who are now working with these interesting and valuable materials.

DISCUSSION

MR. L. L. WYMAN²—Mr. Hoyt's comments on some of the early incidents pertinent to the development of Carboloy in this country are, in many respects, overly modest with respect to his many contributions. Although his personal activities in this area were primarily concerned with tool applications, he enlisted my efforts in this field, in 1926, particularly because this tool alloy was the outgrowth of the efforts of Osram metallurgists to obtain a satisfactory material from which to make drawing dies for tungsten and molybdenum wire.

From the standpoint of wire-drawing die applications, binder contents of down to 3 per cent cobalt were explored, as were carbide powders of widely varying characteristics produced by direct carburizing of tungsten powder using sugar-carbon or other solid forms, by carbon reduction and carburization from tungsten trioxide to tungsten carbide, and by gas carburization using such media as benzene-saturated hydrogen and even illuminating gas.

Having at that time just developed a particle-size control for tungsten powder, I applied this "know-how" to carbide powders, the result being that the final selection consisted of a rather fine powder of specific particle-size distribution together with 6 per cent cobalt, as binder, for tungsten wire-drawing die nibs.

The material at Harrison Lamp Works was consistently harder than Mr. Hoyt's 13 per cent cobalt alloy and gave little variation in hardness. As the result, less attention was given to hardness, and far greater attention was devoted to porosity, "lakes" (small areas of binder, no carbide), and to the flexure test on the $\frac{1}{4}$ -in. sq. by 2-in. bar.

In preparing microsections, the finest diamond "dust" then available was "No. 6," representing that portion still suspended in pure olive oil after 6 months' settling. This was readily available from our own diamond-die polishers, at Harrison Lamp Works, who made various grades of dust by pulverizing worn-out or broken diamond dies. Then later, as Mr. Hoyt

notes, B. W. St. Clair of the West Lynn Laboratory, General Electric Co., came up with his "No. 9" dust made by centrifuging suspended No. 6 dust. This "No. 9" was an abbreviation of 900, the equivalent months of settling St. Clair claimed was accomplished in the centrifuge. As the result of having vastly improved specimen preparation, more attention was devoted to the microstructure, with many beneficial results, among which might be mentioned the observation that longer sintering schedules resulted in the loss of some of the very fine carbide particles and the apparent growth of larger particles. In discussing this with Mr. Hoyt, I was advised that he had observed apparent carbide growth. Later, Mr. Kelley and I studied this effect and published the results showing solubility of the tungsten carbide in cobalt.

Upon joining the staff of the Research Laboratory in 1929, I, too, became subject to the not-incoherent lamentations concerning the breakage of diamond brales when testing hardness of Carboloy. It really was a high-dollar "overhead"—particularly when we got into the depression of the 1930's. This problem caused us to devote quite some effort to an endeavor to learn how to select proper brales; the result was that arrangements were made with the supplier for us to select the ones we desired from a regular production lot which was supplied for that purpose. The selection was based on two criteria: (1) concentricity, spheroidicity, and radius, as revealed by a specially designed, high-magnification "optical comparator," and (2) surface polish and freedom from chipping, as revealed by visual examination under a high-power stereoscopic microscope.

Each staff member engaged in carbide work was assigned his own brale, and when one of these was suspected of giving fictitious results, it was re-examined for imperfections. By adhering to this program, not only did we materially reduce brale troubles but our confidence in hardness determinations was also vastly improved.

As an addendum to Mr. Hoyt's comments on the lack of ductility of Carboloy, either W. R. Whitney or W. D. Coolidge had furnished P. W.

Bridgeman of Harvard University with small rod-like specimens of Carboloy for high-pressure testing. Though reported as having been compressed, our critical examination revealed that the specimen actually had decreased in length, but due to bending. The conviction that the latter was indeed true came only after no meager amount of polemic discussion.

Not long ago I quietly slipped in to the back of the room where a Committee B-9 group was discussing the subject of hardness determinations on cemented carbide blocks and sat down beside a long-time associate, V. E. Lysaght. When someone brought up the subject of brales, we could but stare at each other—probably with the same thought in mind—30 years ago... that's where I came in.

MR. S. HOYT (*author*).—I thank Mr. Wyman for his contribution to the early history of Carboloy. He states that I was "overly modest." I can return the compliment because I regarded him then, as I do now, as the one who really put over the use of Carboloy dies for drawing tungsten wire. After trying out some dies I made at Schenectady, he accepted my cooperation and worked to make successful use of the new material. In the tungsten filament plants, that contribution must have saved the General Electric Co. large sums of money and improved the practice.

To set the historical record straight it was not until after 1925 that Mr. Wyman's help was enlisted. My first task was to learn how to produce good Carboloy tools and to demonstrate by ten consecutive runs that I had mastered the art. These runs were made between February 27 and March 11, 1926. It was later in that year that I turned my attention to wire-drawing dies.

Particle size, distribution, and retention, I may add, are very important in powder metallurgy. I had developed a handy settling test but when Mr. Wyman joined us at the laboratory he soon provided more accurate determinations. They were very helpful in process control by which consistency of performance was benefitted.

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Measuring Specific Gravity of Viscous Materials

By H. E. ASHTON

AT PRESENT, there is no official method for determining the specific gravity of viscous resins. There are, however, official methods for road tars and asphalt cements¹ and for drying oils.² In these methods the procedure varies with the viscosity of the material, but in each the most viscous materials are measured by partly filling the pycnometer with the sample. Distilled water is then added so that it, rather than sticky asphalt or oil, is driven out through the capillary. The only difference between the methods is that in ASTM Method D 70 the pycnometer is completely immersed in a constant-temperature water bath. One of these methods is usually adopted for use with viscous resins.

There are two disadvantages in this type of procedure. First, bodied oils and resins having specific gravities less than 0.95 tend to float on the added water and are partly expelled through the capillary. Secondly, asphalts, oils, or resins have a strong tendency to form air bubbles while being poured into the pycnometer even though the material has been warmed to facilitate pouring. Attempts to remove the bubbles are usually made by warming or centrifuging the pycnometer before weighing and adding the water. While the bubbles rise to the surface, however, they frequently will not break; breaking them with a fine wire is inefficient and usually results in material being spattered on the sides of the pycnometer. Since the materials are hydrophobic the added water does not assist in breaking the bubbles.

Both of these difficulties were encountered in this laboratory in determining the pigment volume concentration of a paint made with bodied (heat polymerized) linseed oil. In an attempt to overcome them, acetone was added in place of water. It was found that acetone wetted the surface of the oil and freed the bubbles without dissolving the

Experience with the present ASTM partly filled pycnometer methods for determining specific gravity of liquid resins resulted in a program to improve the procedure. Solvents of very low solvent power were used in place of the water at present specified. Experiments were conducted on a polymerized linseed oil, an alkyd resin, and an asphalt solution.

Weak solvents wet the surface of the materials enough to release trapped air bubbles but without dissolving sufficient material to cause errors due to shrinkage. In all cases the solvent-determined specific gravity was slightly higher and the results were more reproducible than when water was used. Use of stronger solvents led to high results.



(a) Hubbard-Carmick Pycnometer



(b) Weld Pycnometer

Fig. 1.—Pycnometers.

oil, but owing to the volatility of acetone the accuracy of the specific-gravity determination was not improved. Use of higher homologs of acetone to reduce the volatile loss was not considered feasible because the increased solubility of the oils in the solvents would lead to shrinkage.

The concept of using low-odor and odorless solvents was then developed. These petroleum thinners have low

solvent power, low specific gravity, and low evaporation rate. Low-odor solvent was first chosen for comparison with water as the additive in determining the specific gravity of a bodied linseed oil. It was found that all the bubbles were eliminated and, as expected, the oil did not float.

As a result of this preliminary work a program was undertaken to compare the different procedures for determining the specific gravity of viscous liquids. A series of experiments with two additives, water and odorless solvent, was carried out on three different viscous materials: a bodied linseed oil, an alkyd resin, and an asphalt solution. Two filling techniques were used at first, but one method, hypodermic injection, was eliminated as the work proceeded. Finally, various solvents were tested with the alkyd resin to see whether shrinkage due to solubility is important. All specific gravity results were obtained by the same operator.

Apparatus and Methods

Temperature

All determinations were carried out at 25°C because solvent losses and solubility effects would be greater than at 20 or 15.1°C. The low-softening-point thermometer, graduated in 0.2°C, was used in accordance with Method C in ASTM Methods of Test for Specific

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¹ ASTM Method of Test for Specific Gravity of Road Oils, Road Tars, Asphalt Cements, and Soft Tar Pitches, 1958 Book of ASTM Standards, Part 4, p. 1044.

² ASTM Methods of Testing Drying Oils, 1958 Book of ASTM Standards, Part 8, p. 250.

HARRY E. ASHTON was graduated in 1945 from the University of British Columbia, with First Class Honors in Chemistry. For three years, with The Canadian Fishing Co. Ltd. in Vancouver, his duties included oil analysis, fish product development, and control work. In 1948 he joined the General Paint Corporation of Canada Ltd., also in Vancouver, and performed development work, paint analysis, production statistics, and costing. In 1956 he became an assistant research officer in the Paint Laboratory of the Division of Building Research, National Research Council, Ottawa. His work there has consisted mainly of development and improvement of paint test methods, special product development for government departments, and assistance with specification writing.

Gravity of Industrial Aromatic Hydrocarbons (D 891).³ The calibration of the pycnometers was found to be more reproducible when they remained in the constant-temperature bath for 1 hr instead of the 30 min specified in the three ASTM methods. The bath and analytical balance were kept in a constant-temperature room at $23 \pm 2^\circ\text{C}$.

Pycnometers

Two types of pycnometers were used in this investigation (Fig. 1). Where the specific gravities of the oil, alkyd, and asphalt were determined by addition methods, wide-mouth Hubbard-Carmick pycnometers were used. Weld pycnometers, which have a narrow mouth and a cap to prevent evaporation, were used in accordance with Method C of Methods D 891 for measuring the specific gravity of the solvents and also for checking the bodied oil determination. In this method the pycnometer is completely filled with test material.

The capacities of the pycnometers were calibrated several times by weighing them when filled with freshly boiled and cooled distilled water. Reproducible results were easily obtained with the Weld pycnometers, four determinations on each of the two pycnometers having a range of 0.0012 g. Based on these results, the maximum range on calibration with four determinations should be 0.0023 g at the 95 per cent confidence level and 0.0033 g at 99 per cent. The Hubbard-Carmick pycnometers were not so consistent. One reason for variation is that the pressure used to seat the wide-mouth stopper can be varied considerably with a resulting difference in the amount of water forced through the capillary. It was necessary to calibrate this type several times to get five or six values within a range of 0.003 g. With new pycnometers the first results were always high and they had to be used several times before the stopper became well seated and the weight of the contents ceased to drop. Pycnometers with a bore of about 1 mm gave more consistent results than those with a bore of 2 mm, which Method D 70 allows. The selected pycnometers were rotated among the various methods and materials.

Procedure

In the addition methods using the Hubbard-Carmick bottles, the oil and alkyd resin were warmed at 65 to 70°C for about 1 hr and all bubbles removed before partly filling the pycnometers. The asphalt cutback, which was of the slow-cure type, had to be heated at 105 to decrease the tendency to form bubbles when being poured. After the samples had been placed in the pycnometers they were warmed again for 30 to 45

TABLE I.—SPECIFIC GRAVITY^a OF BODIED LINSEED OIL BY ADDITION METHOD.

	Addition of Water		Addition of Odorless Solvent	
	Poured	Hypodermic	Poured	Hypodermic
Number of determinations	6	6	7	5
Mean	0.96260	0.96270	0.96312	0.96296
Standard deviation of sample	0.00038	0.00052	0.00024	0.00036
Range	0.00116	0.00156	0.00067	0.00097
Coefficient of variation, per cent. .	0.04	0.054	0.025	0.037

^a All specific gravities determined at 25°C in comparison with water at 25°C .

min to allow any bubbles that had formed to rise to the surface and, if possible, to break. When working with asphalt the stoppers were placed on the pycnometers during the warming cycle to reduce any tendency to evaporate. After warming, the pycnometers were cooled in a desiccator and sample weight was determined. The pycnometers were then cooled below 23°C and water or solvent, also cooled, was carefully poured down the side until full. Bubbles freed by the solvent were allowed to rise. The stoppers were put in place and the pycnometers set in the water bath, partially immersed for oil and resin determinations, and completely immersed for asphalt when water was the additive. The bath was maintained at $25 \pm 0.05^\circ\text{C}$ during the final 30 min of immersion. The stopper was then carefully wiped clean and the pycnometer removed from the bath, wiped dry quickly, and weighed. The specific gravity was calculated using the following formula:

$$\text{Specific gravity} = \frac{C - A}{(B - A) - \left(\frac{D - C}{E}\right)}$$

where:

- A = weight of empty pycnometer,
- B = weight of pycnometer plus water,
- C = weight of pycnometer plus sample,
- D = weight of pycnometer plus sample plus solvent (or water), and
- E = specific gravity of solvent at the same temperature, determined according to Method C of Method D 891. With water addition, $E = 1$.

For determinations with Weld pycnometers, only the bodied oil required heating to ensure absence of bubbles. Solvents and water were cooled below 23°C before filling while pycnometers containing oil were cooled before inserting the stoppers. The pycnometers were then partially immersed in the water bath for 1 hr at 25°C . When measuring solvent or water in this type of pycnometer the cap was placed over the capillary after the first large expansion had taken place, to prevent excessive evaporation. After immersion the cap was removed, the stopper carefully seated, and excess liquid removed from the top of the capillary.

It was necessary with linseed oil to moisten the lens paper slightly with benzene to ensure removal of all oil from the outside of the stopper. The cap was then replaced, the pycnometer taken from the bath, wiped dry, and weighed. With this method the specific gravity is equal to $(C - A)/(B - A)$.

Treatment of Results

Because the different methods usually differed only slightly in results, it was necessary to apply a test to determine whether the differences were statistically significant. Student's "t" test, in which the difference between means is divided by the standard error of the difference, was used in all calculations.

Experiments and Results with Bodied Linseed Oil

The specific gravity of a bodied linseed oil with a Gardner-Holdt viscosity of Z2 was determined by the addition method. The purpose of the tests was to compare the addition of odorless solvent with that of water in measuring the specific gravity of a viscous material lighter than water. A parallel experiment was to see whether hypodermic injection of the sample rather than pouring would reduce or eliminate air bubbles. The results are summarized in Table I.

Most of the bubbles formed by pouring broke when the pycnometers were warmed. Any that were left disappeared when solvent was added but remained when water was used. The main body of the oil only floated on the water in one case; in the others a small amount of material could be seen on the surface of the water before the stopper was inserted. Generally, there was a tendency for the oil to creep up the sides of the pycnometer when it did not float. The "t" ratios between the different methods of adding the oil were calculated:

Between pouring and hypodermic with water	0.35
Between pouring and hypodermic with solvent	0.78

These ratios show that there was not a statistically significant difference between pouring or hypodermic injection whether solvent or water was added. The results for each additive were consequently pooled for comparison with results obtained from the Weld pycnom-

³ 1959 Supplement to ASTM Book of Standards, Part 8, p. 190.

TABLE II.—SPECIFIC GRAVITY^a OF BODIED LINSEED OIL. COMPARISON OF METHODS.

	Addition Method		Weld Pycnometer
	Water	Odorless Solvent	
Number of determinations.....	12	12	4
Mean.....	0.96265	0.96305	0.96301
Standard deviation.....	0.00046	0.0003	0.00001
Range.....	0.00156	0.00097	0.00003
Coefficient of variation, per cent....	0.048	0.032	0.001

^a All specific gravities determined at 25 C in comparison with water at 25 C.TABLE III.—ALKYD RESIN SPECIFIC GRAVITY^a BY ADDITION METHOD.

	Addition of Water			Addition of Solvent
	Poured	Hypodermic	Pooled	
Number of determinations.....	7	7	14	8
Mean.....	1.08267	1.08317	1.08292	1.08294
Standard deviation.....	0.00062	0.00026	0.00053	0.00027
Range.....	0.00177	0.0008	0.0018	0.00098
Coefficient of variation, per cent....	0.057	0.024	0.049	0.025
"t" ratios:				
between pouring and hypodermic.....		1.82		
between solvent and hypodermic.....		1.63		
between solvent and all water values.....		0.71		

^a All specific gravities determined at 25 C in comparison with water at 25 C.

eter, which was considered the most accurate and therefore the standard procedure. The summary is given in Table II.

The "t" test was also applied and the following results obtained:

Comparison Between	"t" Ratio	Significance
Water addition and Weld pycnometer.....	2.589	Significant at 95 per cent
Water addition and solvent addition.....	2.401	Significant at 95 per cent
Solvent addition and Weld pycnometer.....	0.442	Not significant

It can be seen that use of odorless solvent gave results not significantly different from those of the Weld pycnometer, while addition of water produced significantly different results. The improvement in accuracy and precision of the addition method is probably due to elimination of air bubbles by the odorless solvent.

Neither additive procedure can compare to the reproducibility of the Weld pycnometer used according to ASTM Method D 891. Unfortunately, Method D 891 cannot be used with viscous materials which retain bubbles for a long time even when warmed. Moreover, the Weld pycnometer to be filled requires about 25 ml, which is large if the sample has to be obtained by centrifuging a pigmented material. The specific gravity of an isolated vehicle can be determined on 5 to 6 g using the odorless solvent as additive.

Experiments and Results with Alkyd Resin

This work was designed to compare the use of odorless solvent to that of water in the addition method of determining the specific gravity of a resin heavier than water and more viscous than the bodied oil previously used. The material selected was a 100 per cent alkyd resin containing 30 per cent

phthalic anhydride and 60 per cent linseed oil and with a viscosity of Z10. Hypodermic injection was compared to pouring the resin when water was added, but not with solvent since bubbles would be released by the latter.

Three runs from the water-addition method had to be discarded because poor technique led to an excessive number of air bubbles. It was found necessary to load the hypodermic very slowly to prevent bubble formation. Pouring the warm resin produced numerous small bubbles, but in contrast to the oil, they were not eliminated by further warming in the pycnometer. Addition of solvent, but not of water, caused the bubbles to break. A somewhat milky layer about $\frac{1}{8}$ in. deep was produced above the resin-solvent interface. The results for the different procedures are summarized in Table III.

With the alkyd, the differences in means between methods were about the same as with the bodied oil, but the "t" test did not show that they were significant because of the large deviation in results obtained with the resin-poured, water-added method. In comparing the solvent-addition and hypodermic-water techniques, where the deviations within methods are small, the difference between methods is also small. It would seem logical that these two procedures, which eliminate the bubbles, would give a higher and more accurate result. The standard deviation and coefficient of variation for the solvent addition are of the same magnitude as for the bodied oil. In the viscous resin, where bubble retention is a problem, the hypodermic method gave better results than pouring the

TABLE IV.—SPECIFIC GRAVITY^a OF AN ASPHALT CUTBACK BY ADDITION METHOD.

	Method D 70, Addition of Water	Addition of Solvent
Number of determinations.....	9	7
Mean.....	0.99786	0.99832
Standard deviation.....	0.00040	0.00027
Range.....	0.00134	0.00088
Coefficient of variation, per cent.....	0.04	0.027
"t" ratio:		
Between water and solvent.....	2.534	
Significant at 95 per cent		

^a All specific gravities determined at 25 C in comparison with water at 25 C.

resin. However, when compared with the solvent method, the results did not compensate for the extra time and trouble required to obtain the specimen without bubbles.

Experiments and Results with Asphalt Cutback

The aim of the tests was to compare the addition of odorless solvent with that of water in determining the specific gravity of an asphalt. A cutback of the slow-cure type was used. The water method, according to Method D 70 specifies that the pycnometers be completely immersed in boiled and cooled distilled water. To achieve this, an evaporating dish with distilled water fresh for each run was immersed in the large constant-temperature bath. Hypodermic injection was not used because it had not been an improvement in the two previous series.

The first results were obtained when the asphalt was warmed to 75 C before pouring it into pycnometers. When some bubbles could still be observed in the pycnometers, especially on addition of solvent which released the bubbles, it was decided to heat the asphalt to 105 C. This procedure markedly reduced, but did not eliminate, bubble formation. After the asphalt was cooled and weighed, the addition of odorless solvent to the asphalt caused some small pieces of material to float in the solvent for a few minutes. This material soon settled, leaving the solvent faintly yellow-brown in color. It was also noted that after water addition the surface of the asphalt was markedly concave.

One value from the solvent procedure was considerably higher than the others. K. R. Nair's statistical test⁴ for permissible deviation of an observation from a sample mean was applied using the previous results as an independent estimate of the standard deviation. It was concluded that the high result was anomalous. Discarding the one result in eight reduced the range, deviation, and variation almost in half. Final results are summarized in Table IV.

⁴ E. S. Pearson and H. O. Hartley, *Biometrika Tables for Statisticians*, Vol. 1, p. 50, Cambridge University Press (1954).

The specific gravity determined by solvent addition was again higher than that obtained by water addition. This difference, which was statistically significant, can be explained by the elimination of air bubbles by the solvent.

Experiments and Results with an Alkyd Resin Using Different Solvents

This work was undertaken to determine whether the strength of a solvent affects the specific gravity as measured by the solvent-addition method. If the material of which the specific gravity is being taken should dissolve, there should be an increase in apparent specific gravity, since the stronger solvents dissolve more material. If shrinkage due to solution is not a factor, then any solvent should be satisfactory for this method.

This series was carried out two months later than the previous work with the alkyd which had been stored in a half-full bottle. Consequently, there was some oxidation with a slight increase in specific gravity. As the work progressed and the alkyd was consumed, oxidation increased and some of the last runs had to be discarded because the specific gravity showed a larger change with time than with solvent. For this reason all solvents were not tested the same number of times. It was not possible to run sufficient samples to establish statistical significance with all the solvents tested nor to compare all solvents of interest. The solvent power of the solvents was measured by the kauri butanol procedure. While this method is not the most precise measure of solvent strength, it does give a fairly good indication and is easy to perform.⁵ The solvents used and their properties are listed in Table V.

There was only one set of duplicates in the specific gravity determinations on the alkyd using these solvents. All other values were obtained on different days for each solvent. Two determinations were made with isooctane, which has a kauri butanol value of 25, but due to its high volatility, the amount of solvent added could not be accurately weighed. All solvents caused air bubbles to be released from the resin surface. There was a difference in appearance, however, after the solvents had been in contact with the resin. In the case of the odorless solvent, there was a narrow band of milky solution up to $\frac{1}{4}$ in. above the interface. With low-odor solvent the milkiness was present throughout the solvent. With increasing solvent strength the resin evidently became more soluble, because the turbidity was just noticeable with

TABLE V.—PROPERTIES OF SOLVENTS USED IN SPECIFIC GRAVITY^a DETERMINATION.

Solvent Type	Kauri Butanol Value, mean	Specific Gravity, mean, 25 deg Cent	Distillation Range, Reported, deg Fahr
Odorless solvent.....	25.8	0.75135	345 to 415
Low-odor solvent.....	29.5	0.76991	360 to 410
Hi-flash spirits.....	34.0	0.77777	330 to 395
Mineral spirits (No. 1).....	37.6	0.78148	310 to 380
Mineral spirits (No. 2).....	41	0.79206	315 to 390
Medium aromatic.....	69.4	0.84611	320 to 375
Hi-flash naphtha.....	87.2	0.88089	315 to 385

^a All specific gravities determined at 25 C in comparison with water at 25 C.

TABLE VI.—SPECIFIC GRAVITY^a OF AN ALKYD RESIN BY ADDITION METHOD USING DIFFERENT SOLVENTS.

	Odorless Solvent	Low-odor Solvent	Hi-flash Spirits	Mineral Spirits, No. 1	Mineral Spirits, No. 2	Medium Aromatics	Hi-flash Naphtha
Number of determinations.....	4	5	6	6	5	6	5
Mean.....	1.08369	1.08390	1.08369	1.08383	1.08386	1.08420	1.08479
Standard deviation.....	0.0002	0.00058	0.00042	0.00057	0.00052	0.00037	0.00064
Range.....	0.00052	0.00164	0.00123	0.00177	0.00147	0.00125	0.00178
Coefficients of variation, per cent.....	0.018	0.053	0.04	0.053	0.048	0.034	0.059
"t" ratio with odorless solvent.....	...	0.674	0.016	0.491	0.620	2.536	3.247

^a All specific gravities determined at 25 C in comparison with water at 25 C.

hi-flash spirits, and all other solvents remained clear. The specific gravity results are given in Table VI.

The "t" test shows that the difference in means between odorless and the other solvents is statistically significant only with the last two solvents. It can be seen, however, that the odorless solvent gave more consistent results than the others. The greater variation with the stronger solvents might be due to variations in manipulation of the pycnometers during the several determinations. Where there is a tendency for the resin to dissolve, the greater the agitation the more material would go into solution, with a resultant higher specific gravity. The odorless solvent, because of its poor solvent power, precipitates any resin that dissolves within a short distance of the interface, so that small variations in agitation from wiping and handling have little effect on the specific gravity determinations.

Figure 2 shows the change in specific gravity with increasing solvent power. There would also be a correlation with the specific gravity of the solvent, but it is believed that solvent strength is the important parameter. The results

from the low-odor solvent are higher and those from the hi-flash spirits are lower than would be expected from their kauri butanol values. The standard deviation should approach that of the odorless solvent as the solvent strength decreases, but as this is not the case, especially with the low-odor solvent, these two series may be subject to operator's error.

Discussion

Although the results were not in all cases significantly different from those obtained with water, the use of odorless solvent gave more reproducible results in the determination of the specific gravities of a bodied oil, an alkyd resin, and an asphalt cutback. The solvent procedure is also faster since fewer precautions have to be taken to eliminate air bubbles. Simple warming of the pycnometer to cause the bubbles to rise to the surface is all that is required since the solvent will cause the bubbles to break.

Hypodermic injection of the sample is not considered practicable. With linseed oil, air bubbles disappeared,

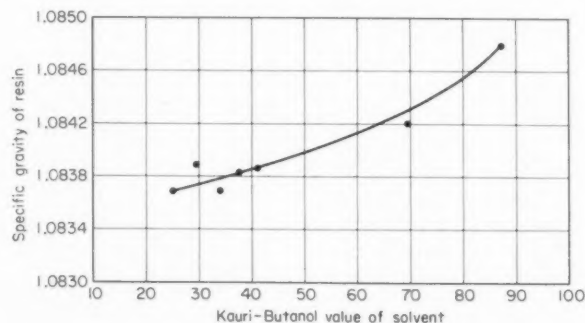


Fig. 2. Solvent strength versus specific gravity of alkyd resin.

⁵ W. W. Reynolds, "Solubility of Paint Resins in Hydrocarbon Solvents," *Official Digest*, Federation of Societies for Paint Technology, Vol. 29, No. 393, p. 977 (1957).

and pouring the oil gave results similar to the hypodermic whether water or solvent had been added. Where bubbles remained, adding solvent to the poured resin freed the bubbles and made it as accurate as the hypodermic.

For specific gravity measurements on viscous materials, it is believed that the solvents should be restricted to those with kauri butanol values of 27 or lower and with distillation ranges high enough to eliminate all but a trace of evaporation through the capillary.

It is concluded that ASTM Method D 70, as presently written, with the addition of water, is capable of better precision than the range of 0.005 now given. Based on the results given in

Table IV, four values from the same operator should have a maximum range of 0.0028 at a confidence level of 99 per cent. The maximum diameter of the hole in the stopper should be lowered in order to reduce variations in calibrating and in using the pycnometers. It is recommended that the immersion time in Methods D 70, D 555, and D 891 be lengthened to 1 hr, especially for the calibration with water.

It was noted in Method D 70 that the precautions advise heating viscous asphalts to 100 C and then pouring out to facilitate cleaning the pycnometer. The author has used with success cold chloroform or trichlorethylene for removing asphalt as well as alkyd resins

and bodied oils. The chlorinated solvents, being heavier than the materials, readily dissolve them without heat.

Acknowledgment:

The author is indebted to Mr. G. A. O'Doherty of the National Research Council, Paint Laboratory, for measuring the kauri butanol values. Thanks are due to R. J. Brown Co. Ltd. for supplying specimens of some of the solvents. This is a contribution from the Division of Building Research, National Research Council of Canada and is published with the approval of the director of the division.

Technical Note

An Erosion Test for Soils

By ANTON L. Inderbitzen¹

IT IS NOW possible to determine in the laboratory how much erosion will take place on a hillside fill for given storm conditions. An apparatus devised by the author allows the user to determine how erosional rates for a given soil are affected by: relative compaction of the soil, slope of the experimental "hillside," rate of water flow, and duration of water flow. Erosive medium for the experiment is sheet run-off, but the apparatus could be modified to introduce the action of raindrops. Erosion of the soil specimen is measured on a weight basis and calculated as a percentage of the original dry weight. This test is but a rough approximation of field conditions, and the results should be interpreted in a qualitative rather than a quantitative manner.

Apparatus

The equipment consists mainly of a wooden tray with sides, a tapered front end, and a large circular hole in the center (Fig. 1). A piece of $\frac{1}{4}$ -in. ID copper tubing is attached to the rear of the tray. Holes $\frac{1}{16}$ -in. diam on 1-in. centers are punched the length of the tubing at the level of the tray bottom. One end of the tubing is clamped shut, and rubber tubing connects the other end to a water tap. Water from the

copper tubing flows down the board as a laminar sheet as long as the water pressure is not too great. Rate of flow is calibrated by marking straight lines on the board where the spouts of water strike the board and coalesce as sheet flow. Successive parallel lines measure successive water flow rates for various water pressures. By marking the board in this manner, various flow

rates, measured in gallons per minute, can be obtained again without re-measuring the flow (see Fig. 1).

A 6-in. ID steel mold with a removable base plate (Fig. 2) fits snugly into the hole in the center of the tray. Soil to be tested is prepared to the desired relative compaction within this mold. Any size or type of soil mold can be used. The larger the diameter

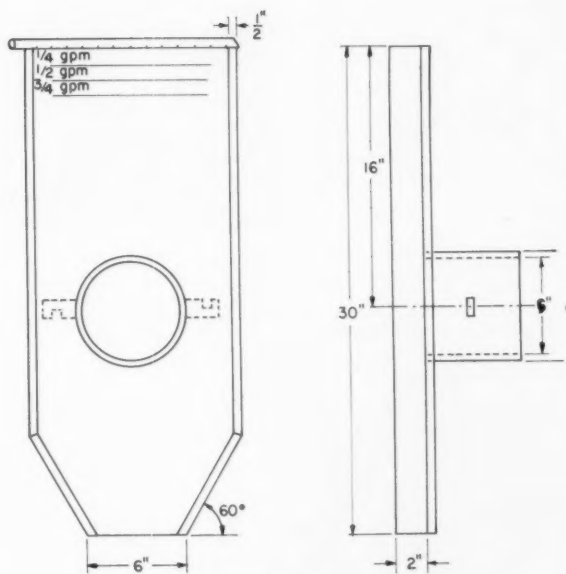


Fig. 1.—Details of the erosion testing equipment.

¹ Engineering Geologist, Lockheed Aircraft Corp., ASW-Ocean Systems Div., Burbank, Calif.

of the mold, the larger the area of soil exposed, and the more accurate the test results.

A No. 200 Tyler sieve is placed on a wooden rack over a sink below the tapered end of the tray. Material finer than the No. 200 sieve is trapped below it in a settling tank.

Procedure

Soil to be tested is prepared in the mold to the desired relative compaction and its dry weight is determined. The base plate is then removed and the mold inverted and pushed into the hole in the center of the tray until the lip of the mold and the soil surface are flush with the floor of the tray. For best results the soil should be pushed slightly higher than the floor of the tray.

The entire apparatus is then placed next to the sink containing the sieve and tank with the tapered end over the sieve. The tray is tilted to the desired "hillside" angle by placing blocks under the lower lip of the mold. A hand level with a built-in protractor is used to measure the angle of tilt of the tray. Water is turned on to the pressure necessary to obtain the desired rate of flow. As the water flows down the tray and across the top of the exposed soil surface it erodes the soil. Eroded material is carried down the board and into the sieve or tank below. Water is allowed to flow across the specimen for the length of time desired and then turned off. All material collected on the sieve, loose on the board below the specimen, and in the tank, is dried and weighed. Percentage of the total dry weight is then calculated.

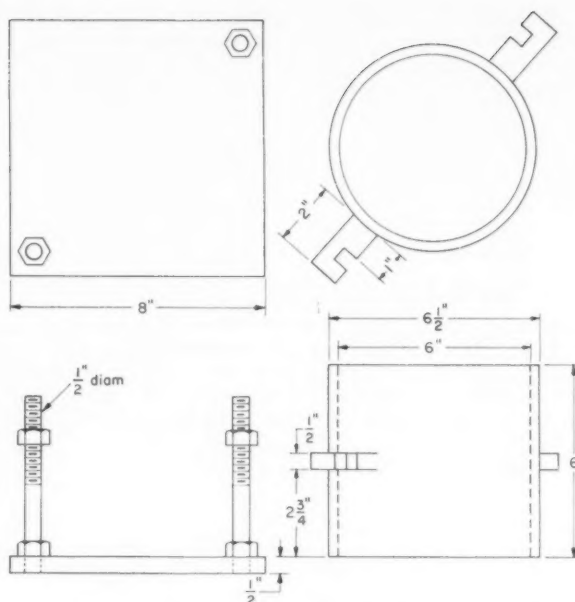


Fig. 2.—Soil mold used in the erosion experiments.

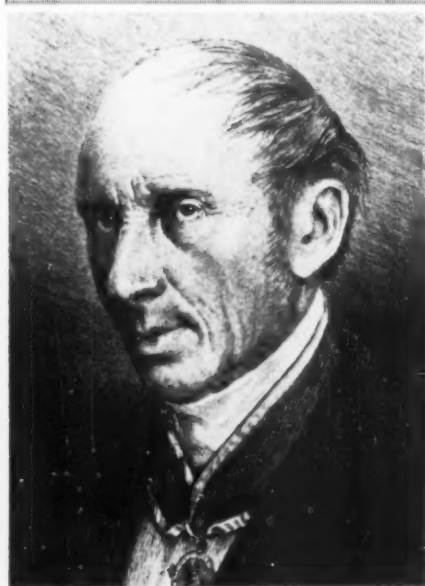
Discussion

Relative compaction at which the specimen is prepared and slope angle of the board depend on the original field conditions. Rate of water flow and duration of the flow over the specimen will depend upon the intensity and concentration time of the rainstorm that is being duplicated in the laboratory.

If needed, a shower-type sprinkler could be placed above the soil specimen to simulate the action of raindrops.

If the sprinkler is used, the rate of flow from the tubing must be lessened to compensate for the rainfall action.

Owing to the lack of complete precision in this test, the results should be considered qualitatively rather than quantitatively. This test merely indicates how rapidly any given soil will erode under different conditions of compaction, slope angle, and storm intensity; it gives the soils engineer and geologist a good idea of how different soils will react to erosive forces when placed in hillside fills.



Augustin Louis Cauchy (1789–1857)

A FRENCH CIVIL ENGINEER, Cauchy was a teacher of both mechanics and mathematics. He laid the foundations of both stress and strain as they are now used in the theory of elasticity. He proposed a theory of torsion of rectangular prisms which called attention to the fact that a normal section does not remain plane as it does in a circular section. He also dealt at length with the problem of vibrating plates.

This is one of a series of photographs from a collection compiled by Prof. Jasper O. Draffin and displayed in the Arthur N. Talbot Laboratory, University of Illinois.

An ASTM for the Future*

By A. ALLAN BATES¹

"In the six decades of its existence, the task of our Society has grown hugely in magnitude but has changed little in principle Now we face the necessity of making profound changes . . ."

FELLOW MEMBERS OF ASTM, this 60th year of our existence under charter as the American Society for Testing Materials finds us in mid-passage between two historical periods so profoundly different one from the other that they cannot be thought of only as "past" and "future." For those of us concerned with materials an "old world" is closing and a "new world" is opening. The future is not to be simply a projection and enlargement of the past. Just as the voyages of Columbus, Magellan, da Gama, and Cabot all in one generation revealed horizons of the earth previously unbelievable, so have explorations among molecules, atoms, and nuclei in our present scientific laboratories opened realms inconceivable in the earlier working years of many present ASTM members.

We all sense the impending great change, dimly. None can foresee its full portents and probably few will quickly appreciate its deeper possibilities for human enrichment. Ferdinand and Isabella bade their voyagers to bring back gold, gold, and more gold, and thus they lost the new world and its earthy wealth a millionfold greater than its gold.

ASTM Has Done Well in the Past

Since its formal birth in March of 1902, the American Society for Testing Materials has uniquely and magnificently served a purpose without which industrial free enterprise in America as we know it would have been impossible. The essence of our American industrial strength lies in our methods of



Retiring President Bates (right) passes the symbolic gavel of authority to incoming President Miles Clair at the President's Luncheon during the 64th Annual Meeting.

mass production, that is, in the production of precisely similar objects in great number. This idea was put into practical use as early as the year 1800 by Eli Whitney. It is a curious fact that Whitney is popularly remembered for his invention of the cotton gin rather than for his infinitely more important idea of mass production. No doubt this is because the popular mind is much more readily captured by a spectacular new object than by a profound new idea, no matter how vastly more consequential the latter may be. Many years after Whitney demonstrated his army rifle made of "standard" reproducible parts, it became evident that standardized materials were a prerequisite to standardized products. This was first realized in Europe and gave rise there to the first societies for

the testing of materials in the 1880's. From these European beginnings there sprang the American Society for Testing Materials.

Profound Changes Are Coming

In the six decades of its existence, the task of our Society has grown hugely in magnitude but has changed little in principle. Our organization, procedures, and objectives remain much as they were in the beginning. Now we face the necessity of making profound changes as a result of deep underlying human developments which, at least ten years ago, began to loom large in our future. That we have only now begun to adjust our Society to the new circumstances is no reason to feel that we have been laggard. The services and functions that ASTM performs for the nation are so basic and so vital that we must do our best to see that they are done with utmost care and competence. In the past, this has always required that we act with studious deliberation. Our technical committees have always seen to it that no important standard was set until all the available technical facts were checked and rechecked by experiment and by experience.

Here lies, precisely, one of the profound changes in procedures and objectives that must be made in our work. Technological progress in materials now advances at an immensely greater speed than was the case in the first year of this century when our Society's committee and administrative structure was designed. Nor is this faster progress only a matter of accelerated proliferation of new materials and combinations of materials. That problem could conceivably be met by a comparable proliferation of ASTM committees.

* Presented at the 64th Annual Meeting of the Society, Atlantic City, N. J., June 25-30, 1961.

¹ Vice-president, Portland Cement Assn., Chicago, Ill.

But we have now entered the era of molecular and microstructural design in which new materials may originate not only in experiment and experience but also through mathematical calculation of macrostructural properties from known physical constants of various atomic and molecular species. This approach may yet be far off and, indeed, may never be used for natively heterogeneous mass materials such as portland-cement concrete. But these rough materials which do not require the utmost refinement in useful performance are not those which will most demand the future attention of the American Society for Testing Materials.

Science Must Supplant Empiricism

During the six decades since its birth, the ASTM has based its work principally upon the great reservoir of practical experience represented in the Society's membership. Only thus could

scientists of all countries who are concerned with materials. In this regard, it would be difficult to conceive of any other agency of equal potential. But if this Sciences Division remains *largely separate* from the rest of ASTM it will fail to fulfill its greater purpose of bringing the new knowledge from the research laboratory directly to the major task of improving the standards necessary to our national industrial life. The truly revolutionary aspect of modern science is its pervasive and dominating immediacy to all phases of western civilization. This immediacy of science to living ASTM standards must be consciously and actively insured by effective liaison between our Division of Materials Sciences and our technical committees which are responsible for standards. I charge my successors in the presidency with the task of developing formal organizational means to this end.

"The truly revolutionary aspect of modern science is its pervasive and dominating immediacy to all phases of western civilization."

the Society have achieved its ends of providing American industry with necessary materials standards. But time is essential to experience, and the urgent challenges of today and tomorrow no longer allow us to treat time as a plentiful commodity. It in no way diminishes the importance of the practical man of experience to be working in a team with the materials scientist. Even the mathematician, made fantastically productive by the electronic computer, may be a fountainhead of ASTM standards in our next span of six decades.

Recognition was given to these trends in the birth last year of ASTM's new Division of Materials Sciences wherein the fundamental characteristics common to all materials are explored. From the work of this new Division there will surely result an orderly generic scientific approach to useful materials standards. The mounting flood of technical information, which is now the dominant and unprecedented aspect of our lives, may thus be a source of strength rather than of confusion. Great credit for vision and persistence are due the Society's recent past-presidents Woods, LaQue, and Kropf, who, strengthened by the deep convictions and able assistance of Executive Secretary Robert Painter, founded the Division of Materials Sciences.

As a *separate* Division it can provide, within the uniquely broad framework of ASTM, the world's most useful and inspiring continuous forum for the

The explosive expansion of science and technology is the basic motivating and controlling force in the 20th-century development of American life. All other forces toward change are derivative and secondary. But some of these are so direct that they can be considered separately. Foremost among these is the vast increase in wealth which arises from the broadening mass applications of advancing science and technology. These mass production procedures are possible only if the resulting wealth is widely distributed. This is just a way of saying that practically everyone in America is now so well paid that we can afford to hire no one to labor in the old unproductive traditional ways. The route from raw material to finished product is therefore made as short as possible and all intermediate labor is eliminated or diminished to the minimum. As part of this trend, the materials producer tends to be a manufacturer of semi-finished products ready for final assembly. This may or may not lessen the demand for standardization of materials, but it certainly increases the pressure for standards governing intermediate or end products. Thus we find ASTM developing standards not only for plastics but also for zippers, not only for cements and concretes but also for pavements of standard skid resistance! Life promises to become complex indeed for an ASTM which is already the world's most complicated technical society. The industrial diplomacy which our suc-

cessors must exercise in the committees, the boards, and the offices of ASTM will have to be of at least as high quality as that devoted to our nation's international relationships. Let no cynic express the hope that it may be even higher.

The onrushing tides of science and technology have also made inevitable an augmented partnership between industry and government which will become much wider and more intimate. Man's new mastery of nature, both in infinite space and in the infinitesimal atomic nucleus, gives him technical powers too great to be exercised by any organization less than the nation as a whole. Indeed, it is already evident that the world's entire society of nations is the smallest organization that can govern many of mankind's most important activities in the next sixty years. The more ardent individualists among us will, of course, resent and resist this development. My own father would have been one of these. He was sure that his beloved steel industry could never survive the eight-hour day when, in effect, this was imposed by government. But, fortunately, man's adaptability to change knows no limits.

The Problem Is National in Scope

Within ASTM we have always had a truly remarkable partnership of industry and government. The cooperation between our member scientists and engineers from Federal and state agencies and those from private industry and from our schools has resulted in the world's greatest and most widely used body of technical standards. I am happy to note that a number of our governmental agencies show an increasing willingness and desire to refer their standards needs to ASTM. But I must also warn that we make progress much too slowly to satisfy the fast-changing requirements of some Federal and state engineering organizations. They, too, are caught up by the winds of technological change, and if ASTM cannot move fast enough to help them control their course they will perforce find their own way. Private industry, which only a few short years ago was the foremost sponsor of scientific research, has now yielded that place to the state. Industry has offered no concerted objection to this transfer of activity and, indeed, has benefited greatly by the economic expansion which has resulted from government-supported research. Let ASTM then be an effective instrument through which private industry and government cooperate in the interests of our national progress, well-being, and security.

The Democratic Way Must Prevail

Over the past year, as most of you know, I have spoken to many audiences

concerning my experiences during the summer of 1960 when, as chairman of an American construction delegation, I had an opportunity to travel widely and with remarkable freedom about the Soviet Union. I have outlined the notable success of the Soviet government in urbanizing and industrializing their huge nation. I have emphasized the central and indispensable part which standardization plays in their fast-mounting industrial strength. From their many central and regional governmental laboratories and academies all standards are issued and all materials progress is directed. The transition of research findings into practical use takes place speedily and efficiently.

Can we match the ultimate Soviet rate of industrial growth? As of 1961 no one can say. Neither their steady growth potential nor ours has been determined, and as of this moment the situations in America and in the Soviet Union provide no basis for economic comparison. We are struggling against a surfeit of technological success which has no historic precedent. We are choking on a uniquely rich diet of over-productivity which we have not found a way to digest. The Soviets, on the other hand, are struggling to emerge from 800 years of an almost continuously dark and tragic history. Beginning with the twelfth-century conquest of all Russia by the Mongol hordes of Ghengis Khan, the people of the Soviet lands have known little but enforced servitude and medieval bondage. Almost untouched by the enlightenment of the Renaissance or the humanism of the Reformation, the people of Russia think that, through science and technology, they now see their way for the first time to salvation. They have an all-absorbing goal—a decent standard of living—which they are fiercely determined to reach. They think they see their way to it and—I urge you to realize—they are moving fast along that way.

What does this have to do with ASTM? A great deal, I believe. In a talk which I have given to numerous ASTM District Councils I have pointed out that our Society is almost the perfect example of "Democracy in Action." I have traced the steps by which democracy originated in urban life, how this urban democracy led to free enterprise and thus on to modern industrialization which, in America, has become synonymous with the mass production of wealth. Finally, mass production is made possible only through standardization. Thus we find America's central society for standards, ASTM, at the very source of our industrial democracy.

The American Society for Testing

Materials is a voluntary association of private individuals, private organizations, educational institutions, and governmental agencies, come together to serve this nation and those of other nations who generously work with us. We all combine our efforts as equals in the vineyard, and the fruit of our labor is freely available to any who choose to take it. This is the way of free enterprise and democracy. To those who do their fair share in the work of ASTM I say, "Well done." To those who go beyond the strict call of duty—and there are more than a few of these—I say, "We are thankful for you and your kind, for it is such as you who have made our way of life possible."

To those who do less than their share of the work—or none at all—I say, "Don't sing a song of free enterprise when you are taking a free ride, for this is the funeral music of democracy."

We face a massive demand to prove that our way of progress is best. The people of the Soviet Union know what they want and they believe they know how to get it. With utmost vigor and speed, they are pressing science into the service of their nation. We cannot quarrel with them for this. It is for us to show that we can do as well, or better, in that task. Industrial materials standards spring quickly from the research laboratory into field use by the Soviet system. ASTM must match that level of effectiveness. If we do not, but become, instead, an impediment to technological progress, then we shall deserve extinction. And when that happens, America will be consciously or unconsciously on its way to the Russian system of governmental industrial control.

ASTM must maintain an alertness to progress and a readiness to change second to no other organization in America. I hope we shall do this not so that we may "beat the Russians" in a race for industrial super-productivity. We have already won that race. The best the Russians can now do is to catch up to us as we continue to move on. I believe we should hope that not only they but all other peoples of the world may likewise "catch up with us" and come to know our absence of hunger and poverty. When we can all take our minds off the struggle for a plenti-

ful material existence, we shall then be able to look to the nobler ends which are within man's capacity and which must be his destiny.

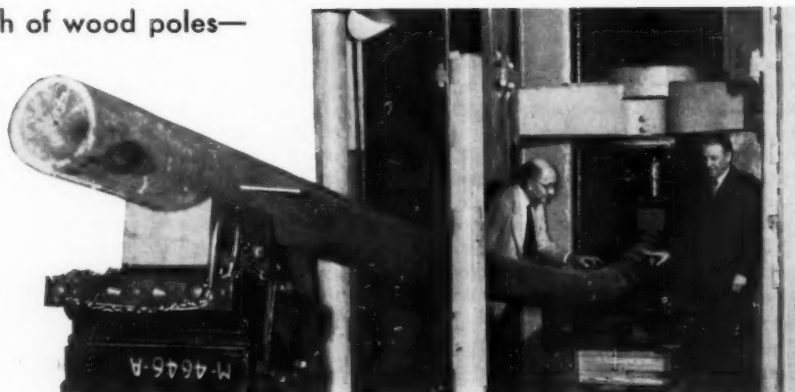
From a higher hill one should be able to see more distant horizons. From the eminence of the ASTM presidency which it has been my privilege to occupy this year, I have tried to discern what lies beyond the immediate forest of ASTM problems and challenges. We have been patiently making our way by unhurried winding paths through the familiar terrain. But not far off there loom some formidable cliffs, and beyond these are mounting ridges which rise to spectacularly high and rugged ranges of new knowledge on the horizon. It is evident that we must conquer these if we are to break out of the confines of the Present. It is obvious that to do this some of us must put on the wings of Science and establish advanced bases high up on the Atomic Cliffs and on the Molecular Mountains. Some must continue to work at extending the pedestrian paths of Experience. But let us never forget that there are other societies and tribes which are eager to reach and occupy the distant summits ahead of us. They will use not only wings but also rockets to span Time, Space, and Matter.

From the president's chair in 1961, I cannot see the routes that ASTM will open up and follow in order to command the scientific and technological heights of 2021. But I see very clearly that the old ways which have served us so well during our first 60 years will be hopelessly inadequate for our next 60. The exponential expansion of our scientific frontiers through research and development will continue unabated. There are a few here assembled who can remember the year 1901, when ASTM was conceived. They know that only since that day we have learned how to release the fundamental forces which move the universe *external* to man. Those here who will eventually remember the year 2001 will know by then that man can release and use his own *internal* capacities to even greater effect upon his own future. We, the present workers in ASTM, are given the privilege of participating in the freeing of man from his own limitations. The future is as bright as we choose to make it.

"Man's new mastery of nature, both in infinite space and in the infinitesimal atomic nucleus, gives him technical powers too great to be exercised by any organization less than the nation as a whole.... Private industry, which, only a few short years ago, was the foremost sponsor of scientific research, has now yielded that place to the state."

Test program on the strength of wood poles—
a case history for

ASTM Research Potential— Unlimited



By L. J. MARKWARDT¹ and L. W. WOOD²

In September, 1960, ASTM published a final report of a \$300,000, six-year study of the strength of wood poles. Here is the story behind one of the largest cooperative research projects ever undertaken within ASTM.

RESearch IS THE KEY to progress in an industrial economy. The advanced weaponry developed during World War II dramatized the already well-known potential of research, and the postwar period has been one of vast growth of research on all fronts. In industry, research is needed for sound growth; in government, it is necessary to meet the obligations of military defense and service to the public.

The founders of ASTM wisely included in its objectives the promotion of knowledge of materials, and, to this end, the Society fosters and encourages research. However, since it does not have any substantial research funds, what can ASTM do to promote and stimulate research?

The progress of ASTM technical committees in the field of specifications and methods of test is largely dependent on research. Fortunately, the Society is able to draw on the experience, knowledge, and background of its

diverse membership from many organizations in the continuing job of developing new standards and improving existing ones. But beyond this, further progress is too often retarded because no one company can justify certain research that can benefit a whole industry. Many projects could be listed in this category in the field of wood and wood-base materials, and similar lists could be compiled in the area of operation of every ASTM technical committee.

While the Society may not be in a position to finance any substantial research, it can be a powerful agency in promoting research through its strong position in the materials field, its good name, the cooperation and assistance of its competent staff, and its publication media. That these facilities can be used very effectively to promote and carry through research projects is exemplified by the ASTM Wood Pole Research Program. This is probably the largest single cooperative research project ever undertaken under ASTM auspices. Six years of work have recently culminated in the publication of a final report.³ Seventy organizations and individuals contributed to the program, which cost some \$300,000. The actual research was carried on in

cooperation with the staff of the U. S. Forest Products Laboratory.

THE ASTM WOOD POLE RESEARCH PROGRAM

That there was a great economic incentive for the ASTM Wood Pole Research Program can be appreciated when one considers the collective size of the industries that produce, treat, and use wood poles. Some 5 million treated wood poles, worth more than \$250 million, are produced annually in the United States. The total capital investment in poles and the operations they serve in the utility field are a multibillion dollar enterprise.

The Problem

The research problem on wood poles arose shortly after World War II. During the war emergency, higher design stresses had been adopted in the American Standard (ASA) specifications and dimensions for wood poles, and in 1948 a question arose as to their continuance. Some inconsistencies in the method of rating the various species of poles were recognized, in that the older species were more conservatively rated than the newer species. It was recognized also that available test data on full-size poles were open to question

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² Civil Engineer, U. S. Forest Products Laboratory, Madison, Wis.

³ "Strength and Related Properties of Wood Poles," ASTM STP No. 290, Am. Soc. Testing Mats. (1960).

because of variations due to moisture content, seasoning, and testing, and that the results did not correlate with the extensive data on tests of small clear specimens.

Project Plans

Recognizing the potential of the Society as a research sponsor, Committee D-7 on Wood in 1949 and 1950 outlined a research program (*see box*) and plans were made to solicit contributions and get it under way. Some indications of financial support were apparent, but the need of a broad participation by all interested parties was essential.

At the 1952 ASTM Annual Meeting in New York, a small group called together by the chairman of Committee D-7 developed a plan of action to initiate the wood pole program. A special conference at ASTM headquarters on August 26, 1952, appointed two special task groups, one a technical advisory task group to supervise and direct the research program, with R. P. A. Johnson of the Forest Products Laboratory as chairman, and the other a ways and means task group to implement the program, with Gen. L. G. Smith of Baltimore Gas and Electric Co. as chairman. Soon afterward, on recommendation of the committee for use in the research program, two standard methods of testing wood poles were adopted by the Society. Plans for the research program were publicized in the ASTM BULLETIN and through other channels. The program was on its way. The original task group chairmen and committee members provided guidance during the program.

The Program Grows

Original plans called for a two-year program for four species of wood at a cost of \$150,000. The research actually got under way on February 4, 1954, with the testing of the first western larch pole. As the program developed and a fifth species was added, it became apparent that the work could not be completed in two years and that the total cost would considerably exceed the estimate. Contributions were then invited on a three-year basis, and the support was gratifying. With the completion and distribution of the final report in 1961, the work had actually covered a six-year period at a total cost of some \$300,000.

The service of the Society in sponsoring such a program was particularly helpful and significant. Contributions to the program were channeled to the ASTM treasurer, where they were earmarked in a special fund. Some accrued interest, pending withdrawal of allotments as the work progressed, was added to the fund. Assistance was rendered by L. C. Gilbert and others of

the ASTM staff without charge to the program. No paid solicitors were employed, and no travel expenses by committee members were charged to the fund. The only indirect costs involved some technical services by a specialist employed at ASTM headquarters for about a year in analyzing the problem.

The committee unanimously endorsed the selection of the U. S. Forest Products Laboratory as the research agency. This was fortunate for several reasons. It not only afforded complete research facilities, but the nationwide services of the Forest Service Regional Offices and the several Forest and Range Experiment Stations were made available to assist in the identification and selection of the poles in the forest and to expedite shipment to the Laboratory. The Forest Products Laboratory contributed importantly in manpower and equipment and provided, at its own expense, a large concrete soaking tank for holding the full-size poles in a soaked condition until they were tested. A further advantage was the participation of several other Governmental agencies in the program, by the transfer of funds directly to the Laboratory. The Laboratory itself was also able to participate in this way. These were particularly favorable aspects that, of course, could not necessarily be duplicated in other ASTM programs.

In planning the research program and limiting its scope to reasonable bounds, it was necessary to omit certain desirable studies on which data were also needed as a basis for more precise specifications. Examples include such studies as the effect of natural characteristics and of seasoning on strength.

During the program, problems came up that suggested sideline explorations, but the task group steadfastly adhered to the outlined program. Later in the work, a supplemental study was separately financed and undertaken to explore the effect on strength of different temperatures as encountered in commercial wood preservation, conditioning, and treating processes.

Selection of Test Specimens

In the course of the program more than 600 untreated and treated full-size poles and 14,000 matched small clear specimens were tested for strength and related properties. The species were southern yellow pine (differentiated into longleaf, slash, shortleaf, and loblolly pines), Douglas fir, western larch, lodgepole pine, and western red cedar, these being the major pole species used throughout the country.

Selection of test poles was in itself a cooperative project of some importance. The Forest Products Laboratory and the regional Experiment Stations of the U. S. Forest Service cooperated in selecting the locations for sampling and made the final selections of poles. A number of pole producers generously contributed their plant facilities and the manpower necessary to meet the rigorous specifications set up for the sampling. To distinguish the southern pines beyond doubt, specimens of the foliage were taken from each pole tree for laboratory identification. The Western Electric Co. furnished inspection on all selected poles to assure comparability of grade among the various species.

All testing of poles and small clear specimens and analysis of the results

The Wood Pole Program at a Glance...

Research Objectives:

- Basic strength of untreated and treated poles.
- Relation of strength of poles to strength of small clear specimens.
- Effects on strength of knots, spiral grain, checks, splits.
- Effect of preservative treatment on strength.

Principal findings:

- Pole strength is related to specific gravity of wood.
- There is a significant correlation between strength of poles and strength of small clear specimens.
- Natural characteristics such as knots and spiral grain as presently limited in American Standards are not an important factor in the strength of poles as they are commonly used.
- Reduction in strength due to conditioning and treatment of southern pine poles was greater for the poles than for the small clear specimens.
- Lodgepole pine and western red cedar poles showed no significant change in strength following air seasoning and treatment in accordance with AWPA 1960 standards.
- The two standard test methods gave essentially similar strengths except for the 55-ft poles.

were done at the Forest Products Laboratory under the direction of the Technical Advisory Group. Thirteen interim reports were issued before the final report, all of these being reviewed by the Technical Advisory Group before issuance. When the results showed the need for a supplementary series of tests, arrangements were made for them under the supervision of a special task group, and the results were fully correlated and integrated into the main program.

Copies of 13 interim reports and of the final report were furnished to all cooperators and were made available to the technical committee members. The final report is now in the hands of ASA Sectional Committee 05 on Wood Poles and is being used as a basis for revision of the present American Standard.

Many Questions Remain

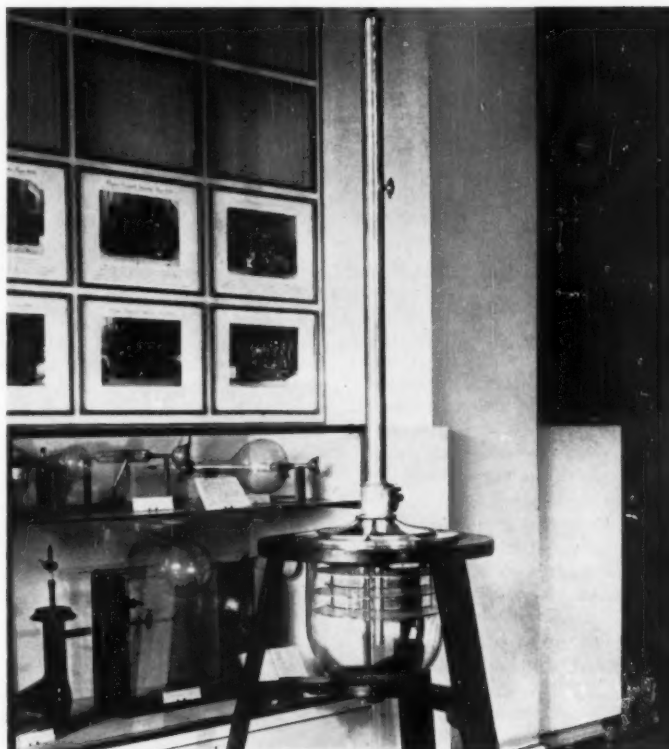
It would be good to be able to report that all of the objectives were fully achieved and that the data provide a simple answer to the establishment of design stresses for different pole species. It has been said of research, however, that it sometimes raises as many questions as it answers, and that the quest for truth must ever be pursued. This was the case in the pole program. It has provided a wealth of data on the strength of full-size poles and small clear specimens and on the effect of various treatment conditions on strength. It has not provided clear-cut answers to all the questions that were raised. The final report lists the following as areas for future research:

1. Effects on strength of machine shaving compared to hand peeling.
2. Effects of butt soaking compared to full-length soaking of test poles.
3. Effect of incising on strength.
4. Specification of poles by specific gravity.
5. Moisture content of poles in service, and effect of drying on strength.
6. The effect of conditioning and preservative treatment on strength. Although this was investigated in some detail, it was concluded that this whole broad field needs more study.

This example of an ASTM research project undertaken under the sponsorship of one of its technical committees is cited as a case history of what can be accomplished when a problem of sufficient general interest and importance presents itself and a proper climate exists for its solution.

The Wood Pole Research Program has effectively demonstrated the potential of the ASTM as an agency for sponsoring research in the materials field, and particularly cooperative research where a large number of interested organizations are involved.

Maxwell's Measurement of the Viscosity of Gases



Cavendish Laboratory, Cambridge, England

James Clerk Maxwell's experimental investigations in support of his theories about gas molecules were mainly carried out in his spare time in the attic of his London house in 1865. Using circular glass plates—a sandwich of fixed and oscillating plates—mounted on a long thread in a container, he was able to confirm the surprising result that the viscosity of a gas did not depend on its density or pressure. He also found that it varied directly with the absolute temperature instead of only as its square root as would have been the case if the molecules were hard balls without force acting between them. Neighbors had been surprised to see Maxwell spend hours at his garret window staring into a coffin (it was his color-box spectroscope); now they were further amazed to see Mrs. Maxwell stoking a great fire in the room for several days in torrid midsummer, then stopping the fire and filling the room with blocks of ice. The temperature variation had unexpectedly proved very interesting but the apparatus was too large for any other constant temperature enclosure. The original apparatus is preserved in the museum of the Cavendish Laboratory, Cambridge.

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Society Affairs

New Officers; Honors and Awards

At its 64th Annual Meeting, the last week in June, in Atlantic City, the Society elected new national officers and honored a number of its distinguished members for their service to ASTM and for their technical achievements.

New President

Miles N. Clair has been president of The Thompson and Lichtner Co., Inc., Brookline, Mass., since 1950. A native of Pennsylvania, he was educated at Drexel Institute of Technology, where he received his B.S. in Engineering in 1921, and at Massachusetts Institute of Technology, where he received his S.M.C.E. in 1923. Drexel conferred upon him the honorary degree D.E. in 1960.

President-elect Clair taught civil engineering at Drexel from 1923 to 1925, then joined Thompson & Lichtner as engineer in charge of testing and inspection. He became vice-president in charge of engineering in 1928, first vice-president and treasurer in 1930, and president in 1950.



PRESIDENT CLAIR

Dr. Clair first became associated with ASTM in 1927 as representative of Thompson & Lichtner on the cement and concrete committees. He still serves on both and also represents his company on the soils committee. He represents ASTM on the Construction Standards Board of the American Standards Assn. and serves as vice-chairman. He has served on the Administrative Committee on District Activities since 1949, as chairman since 1958.

He has been instrumental in the development of lightweight concrete roof slabs and the use of concrete made with fine and coarse cinders for structural purposes. His firm has been associated with many important construction projects in the United States and abroad.

He is past-president of the New England Section, American Society of Civil Engineers; past-president of the Boston Society of Civil Engineers; past-director of American Concrete Inst., which he represents on ASA Sectional Committee A1; a member of ASA Committee on Reinforced Gypsum; and a member of Tau Beta Pi and Phi Kappa Phi. He is a recipient of the Clemens Herschel Prize Award offered by the Boston Society of Civil Engineers, and is the author of numerous technical papers and sections of engineering texts and handbooks.

Dr. Clair is active in many civic organizations. He recently received the Bronze Keystone Award for his services to the Boys' Club of America. He is past-president of the Salvation Army Assn., national councilor of the USO representing New England, and a member of the committee to revise the Boston building code section on concrete.

New Vice-President

Alfred C. Webber is assistant to the laboratory director in the Research and Development Division of the Polychemicals Department at du Pont's Experimental Station near Wilmington, Del. He joined du Pont in 1942 as a physicist at the Arlington, N. J. plant. Four years later he was made a supervisor, and in 1950 he was transferred to the Experimental Station in the same capacity. In October, 1957, Mr. Webber was promoted to senior supervisor, and in 1961 to his present position. Since 1958 he has been coordinator of publications for the Polychemicals Department Research and Development Division.

Born in Lisbon Falls, Me., Mr.



VICE-PRESIDENT WEBBER

Webber received his B.S. degree *cum laude* from Bates College, Lewiston, Me., in 1928, and his M.A. in physics from Boston University in 1940. Mr. Webber taught science at Franklin, Mass., high school from 1928 to 1934. For the next eight years he taught science, biology, and physics at the Brookline, Mass., high school. During the summer months of these years he worked at the Telechron Corp. and the National Research Corp.

Mr. Webber has been a du Pont Polychemicals Department representative on the ASTM plastics committee since 1942 and has served as chairman for many of its subcommittees. He was first vice-chairman of the main committee from 1956 to 1960. From 1954 to 1957 he was vice-chairman of Committee E-1 on Methods of Testing, and since 1957 he has served as chairman. Mr. Webber has been a director of ASTM since 1958 and was chairman of the Committee on Lectures and Awards this past year.

Mr. Webber was a member of the American delegation to the International Organization for Standardization TC 61 on Plastics from 1956 to 1959. He was also a representative on the Coordinating Committee on Atmospheric Conditions in Paris in 1957. Mr. Webber has been chairman of the National Academy of Sciences-National Research Council Materials Advisory Board Continuing Review Committee for Organic Materials since 1958. He is a member of the Optical Society of America.

Six New Directors



Ardrey M. Bounds is chief metallurgist for the Superior Tube Co., Norristown, Pa., where he is in charge of laboratories and technical services

which include the production metallurgy, development metallurgy, chemistry, and electronic laboratories as well as sections devoted to technical service, raw materials, and welding.

Mr. Bounds took his B.S. in metallurgical engineering at Lehigh University in 1933 and his M.S. in 1936. He joined the Superior Tube Co. the same year, shortly after its organization, and has spent his entire professional career in the tubing industry. He established the first widely used system of temper designation in that industry

and developed the high-stiffness stainless hypodermic needle. He designed and built some of the early controlled-atmosphere generators and furnaces and has worked on the theoretical and practical aspects of the function of the base metal in thermionic emission from indirectly heated cathodes. He has worked extensively with fabrication techniques for the refractory metals, zirconium, titanium, vanadium, molybdenum, thorium, columbium, and tantalum.

Mr. Bounds holds a series of patents on cathode nickel alloys for indirectly heated cathodes. He is an active participant on a number of industry specification committees covering steel tubing, aircraft tubing, electron tube materials, reactive metals, and ferrous and non-ferrous metals.

Mr. Bounds is vice-chairman of ASTM Committee B-2 on non-ferrous Metals and Alloys, having been active on this committee since 1955. Other committee activities include service on Committees A-1 on Steel and F-1 on Materials for Electron Tubes and Semiconductor Devices.

Mr. Bounds has been chairman of the Philadelphia Chapter of the American Society for Metals and was instrumental in setting up the first Junior ASM activity. He has been active on several of the ASM national committees as well. He is a member of the American Iron and Steel Inst., American Institute of Mining, Metallurgical and Petroleum Engineers, and the Franklin Institute's Committee for Science and the Arts.



Albert G. H. Dietz is professor of building engineering at Massachusetts Institute of Technology. A native of Lorain, Ohio, Dr. Dietz received his B.A. degree at Miami University, Oxford, Ohio, in 1930. He received his B.S. degree in 1932 and his D.Sc. degree in 1941, both from MIT.

Dr. Dietz joined the staff of MIT's Department of Building Engineering and Construction in 1934. He has had several leaves of absence to the Forest Products Laboratory as senior engineer, and to the Office of Scientific Research and Development as field service consultant, director of the plastics research laboratory impact program, and member of the Solar Energy Committee.

In ASTM Dr. Dietz represents MIT

on the wood, adhesives, and joint sealants committees. He represents Committee E-6 on Methods of Testing Building Constructions on Committee D-20 on Plastics. He has been active on Committee D-20 since 1946 and presently serves on a number of subcommittees. He is also an active member of Committee E-1 on Methods of Testing. In 1948 Dr. Dietz was a joint recipient of the Richard L. Templin Award; in 1957 he received the ASTM Award of Merit.

Dr. Dietz participates in many professional societies. He has been chairman of the Committee on Plastics Education of the Society of the Plastics Industry, and is on the Committee on Mechanics of Materials of the American Society of Civil Engineers. He is a fellow in the American Association for the Advancement of Science and a member of the Forest Products Research Society, the American Institute of Physics, the Boston Society of Civil Engineers, the Society for Experimental Stress Analysis, the Society of Plastics Engineers, The American Society of Mechanical Engineers, the American Society of Electrical Engineers, and the American Institute of Mining, Metallurgical and Petroleum Engineers. He is a recipient of the Desmond Fitzgerald Medal from the Boston Society of Civil Engineers. He is a member of Beta Theta Pi, Phi Beta Kappa, Tau Beta Pi, Sigma Xi, and Tau Kappa Alpha.



Bruce W. Gonser, technical director, Battelle Memorial Inst., has been identified with metallurgical research for nearly 40 years. He has written

nearly a hundred research papers and technical articles and has made many appearances before technical groups throughout the United States and several European countries.

Dr. Gonser received his degree in chemical engineering from Purdue University in 1923. Following his graduation, he served for a year as a research fellow at the University of Utah and while there completed requirements for his M.S. in metallurgy. He gained experience in varied extractive metallurgy operations in the West as a metallurgist and chemical engineer with the American Smelting and Refining Co. He then went to Harvard, where he earned a D.Sc. degree in non-ferrous metallurgy and metallography. After a brief return to industry he joined Battelle in 1934.

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Since joining Battelle, Dr. Gonser has initiated studies on the properties and development of uses for such metals as titanium, molybdenum, germanium, zirconium, chromium, vanadium, thorium, rhenium, tantalum, columbium, and the rare earths. He was among the first to begin research on deposition and coating of metals by the decomposition of vaporized metal halides.

Dr. Gonser has been active in ASTM since 1936, when he represented Battelle on Committee B-6 on Die-Cast Metals and Alloys. He has served as chairman of Committee B-2 on Non-ferrous Metals and Alloys from 1948 to 1960. His membership on the Administrative Committee for Research has extended from 1953 to 1961, six years of which he served as chairman. Other ASTM activities include membership and the Council of the Materials Sciences Division and the Ohio Valley District Council. He received the ASTM Award of Merit in 1956.

Dr. Gonser has headed the work of the International Tin Research Inst. in this country. He has been active in the American Society for Metals, the American Institute of Mining, Metallurgical and Petroleum Engineers, and the Society of Automotive Engineers. He has served as chairman of the Titanium Committee of the Metallurgical Advisory Board of the National Research Council and as a member of the Division of Engineering and Industrial Research of the National Research Council-National Academy of Sciences. Other affiliations include the American Ordnance Assn., American Association for the Advancement of Science, American Electrochemical Society, Institute of Metals, Wire Assn., and Sigma Xi.



Wayne A. Kirklin is manager of Analytical Division of the Hercules Research Center, Hercules Powder Co., Wilmington, Del.

A native of Indiana, Mr. Kirklin was graduated from Indiana University. In 1926 he joined Hercules as a chemist at Kenvil, N. J., and in 1931 moved to Wilmington, Del., as head of the company's central Analytical Div.

Mr. Kirklin first became active in ASTM in the early 1940's through collaborative work on rosin and turpentine in the naval stores committee, which he has served as secretary since 1943. He is chairman of the industrial chemicals committee and he is also

his company's representative on the paint committee.

Mr. Kirklin is a member of the Society's Administrative Committee on Standards and of the Materials and Testing Standards Board of the American Standards Assn. For many years he has been concerned with methods of testing and standardization of product quality tests for Hercules.

Mr. Kirklin has been active in the American Chemical Society, serving as a councilor in 1948, chairman of the Division of Analytical Chemistry in 1949, and a member of the Advisory Board of *Analytical Chemistry*, 1950-1952. He is presently alternate councilor for the ACS Delaware Section and a member of the ACS Committee on Standardization Relations. From 1947 to 1955 he was a member of the International Union of Chemistry Commission on Standardization of Laboratory Materials. He is also a member of the Society for Applied Spectroscopy, the Research Society of America, and the American Association for the Advancement of Science.



Gordon M. Kline is chief of the Organic and Fibrous Materials Division at the National Bureau of Standards,

which includes sections working on rubber, paper, textiles, leather, plastics, dental materials, and polymer structure.

Dr. Kline was born in Trenton, N. J. He took his A.B. at Colgate University in 1925, his M.S. at George Washington University in 1926, and his Ph.D. at the University of Maryland in 1934. He joined the National Bureau of Standards staff in 1929 and became the first chief of the Plastics Section in 1935. He was promoted to division chief in 1951.

His participation in ASTM activities began in 1937 with the formation of the plastics committee, which he served as chairman from 1948 to 1952. Since then he has served on a number of its subcommittees, including the Advisory Subcommittee. Since 1943 he has served on the Subcommittee on Flat Glass of the ASTM glass committee.

Dr. Kline represents the National Bureau of Standards on the adhesives committee, Subcommittee 14 of the test methods committee, the committee on flexible barrier materials, and Subcommittee 8 on Dictionary Usage of the nomenclature and definitions committee. Since 1949 he has represented the plastics committee on the Sub-

committee on Conditioning of Committee D-9 on Electrical Insulating Materials. In 1954 he received the ASTM Award of Merit.

Dr. Kline has also been active in the work of the International Organization for Standardization TC 61 on Plastics and was chairman of eight annual meetings held from 1951 to 1958. He is technical editor of *Modern Plastics* and editor of *Analytical Chemistry of Polymers*. He received the Honor Award of the Washington Section of the American Institute of Chemists in 1951, and the Exceptional Service Gold Medal Award of the U. S. Department of Commerce in 1953. Since 1956 he has served on the ASTM Special Administrative Committee on Nuclear Problems and since 1957 has been the American Standards Assn. representative for Committee B 72 to the U. S. Department of Commerce. He is a member of the American Chemical Society, American Institute of Chemists, The American Society of Mechanical Engineers, Society of Plastics Engineers, Society of Plastics Industry, Washington Academy of Science, Phi Beta Kappa, and Sigma Xi.



James B. Rather, Jr. holds a dual position with the Socony Mobil Oil Co., Inc. He is the coordinator in charge of toxicology and air

and water pollution for the Socony Mobil Research Dept. and also administrative director of Socony's Brooklyn, N. Y., laboratory. Born in Bryan, Tex., he received his B.S. degree in chemical engineering from Lehigh University in 1932 and attended the Harvard Graduate School of Business Administration in the years 1932-1933.

Mr. Rather entered the petroleum industry in June 1933 as a process engineer for Max B. Miller & Co. He joined Socony two years later. In 1937 he was made assistant chief chemist of Socony's Beaumont laboratory and later that year was transferred to the Brooklyn laboratory, where he has held a broad variety of technical and managerial positions. Prior to his present position at Brooklyn

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Laboratory, he was supervisor of the Lubricants Section, supervisor of the Chemical and Automotive Engineering Groups, supervisor of the Analytical and Fuels Section, and assistant manager.

Mr. Rather has been active for many years on the ASTM petroleum committee. At present he serves on the Advisory Committee, is vice-chairman of Technical Committee A on Gasoline, is a member of several other subcommittees.

In 1958, Mr. Rather received the ASTM Award of Merit. He currently serves on the Administrative Committee on Standards and the New York District Council.

Mr. Rather is a member of the American Petroleum Inst., serving on various committees concerned with air and water pollution, and as technical advisor on the Medical Advisory Committee. He is also chairman of the Materials and Testing Standards Board of the American Standards Assn.

"Industrial materials standards spring quickly from the research laboratory into field use by the Soviet system. ASTM must match that level of effectiveness. If we do not, but become, instead, an impediment to technological progress, then we shall deserve extinction."

A. A. BATES
(See p. 555)

YOUR HOSTS...

At the 64th Annual Meeting were the members of the Philadelphia District Council. As they have so often in the past, these capable men played an important part in the meeting arrangements.

Chairman of the District Council is H. W. Stuart, U. S. Pipe and Foundry Co.; arrangements for the dinner and entertainment were made by W. F. Bartoe, Rohm & Haas Co.; and Tinius Olsen 2nd, Tinius Olsen Testing Machine Co., was in charge of ladies' entertainment.

40-, 50-, and 60-Year Members

THE FOLLOWING long-term members of the Society were recognized

at the Annual Meeting and presented with membership certificates:

60-Year Members

Company Members

American Foundrymen's Soc.
American Steel and Wire Div., U. S. Steel Corp.
Bethlehem Steel Co., Inc.
Booth, Garrett, & Blair
The Colorado Fuel and Iron Corp.

Franklin Inst.
Robert W. Hunt Co.
The Lowe Brothers Co.
National Tube Div., U. S. Steel Corp.
John A. Roebling's Sons Div., The Colorado Fuel and Iron Corp.
U. S. Steel Corp.

50-Year Members

Individual Members

S. H. Graf
S. H. Ingberg
Monroe L. Patzig

Company Members

Alco Products, Inc.
Baldwin-Lima-Hamilton Corp.
Bridgeport Brass Co.
Carnegie Institute of Technology
General Motors Corp.

Hercules Cement Co., Division of American Cement Corp.
Ledoux and Co.
Northern Electric Co., Ltd.
Pratt and Lambert, Inc.
The Steel Company of Canada, Ltd.
U. S. Department of the Navy, Bureau of Naval Weapons
U. S. Department of the Navy, Bureau of Ships
U. S. Gypsum Co.
U. S. Naval Engineering Experiment Station

40-Year Members

Individual Members

Arthur F. Brown
J. F. Calef
Carl M. Duff
F. Malcolm Farmer
Raymond E. Hess
J. J. Laudig
Albert W. Luhrs
Vincent T. Malcolm
John W. McBurney
Alvord P. Meng
Andre Millot
Mortimer F. Sayre
W. A. Selvig
Sam Tour
J. C. Witt

Company Members

American Ceramic Society, Inc.
Atlas Powder Co.
Bareco Wax Co., A Division of Petrolite Corp.
Boston Edison Co.
Bridgeport Public Library and Reading Room
The British Electrical and Allied Industries Research Assn.
The Budd Co.
California Institute of Technology
Canada Department of Mines and Technical Surveys, Mines Branch
Esso Research and Engineering Co.
B. F. Goodrich Footwear and Flooring Co., Division of the B. F. Goodrich Co.

Hercules Powder Co., Research Center
Houdaille Construction Materials, Inc.
Houston Public Library
Kansas City Public Library
Kansas State University, Road Materials Laboratory
Koppers Co., Inc., Tar Products Div.
University of Manitoba, Engineering Library
Marquette University, College of Engineering
Missouri Pacific Railroad Co.
University of Missouri
New York State Library
Northwestern States Portland Cement Co.
H. C. Nutting Co.
The Ohio Steel Foundry Co.
The Free Library of Philadelphia, Serials Section
Pittsburgh Steel Co.
Precision Thermometer and Instrument Co.
Sheffield Div., Armco Steel Corp.
Solvay Process Div., Allied Chemical Corp.
South Dakota School of Mines and Technology
Arthur H. Thomas Co.
State of Washington, Department of Highways
University of Western Australia, School of Engineering
J. H. Williams and Co.
Public Library of Youngstown and Mahoning County

Five Receive Honorary Memberships

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An honorary member is a person of widely recognized eminence in some part of the field that the Society covers or one who has rendered especially meritorious service to the Society. He is elected only by unanimous vote of the Board of Directors on a letter ballot. This is the highest honor that the Society can bestow.



Edward J. Albert is chairman of the board, Thwing-Albert Instrument Co., Philadelphia, Pa. A native of Inghams Mill, N. Y., Mr.

Albert began his career as a salesman for Ingersoll-Rand Co. and then was associated with Canadian Allis-Chalmers Co. from 1908 to 1918 in the sales, engineering, and design divisions. He studied mining at the University of Toronto. In 1918 he joined Thwing Instrument Co. and was successively secretary, general manager, and treasurer. The successor company, Thwing-Albert Instrument Co., was formed in 1935 with Mr. Albert as general manager. He was later appointed treasurer and from 1946 to 1957 was president. He became chairman of the board of directors in 1957.

Mr. Albert joined ASTM in 1930. He is an active member of the committees concerned with paint, paper, electrical insulating materials, textiles, and casein. He has also served on several subcommittees of Committee E-1 on Methods of Testing. Mr. Albert was a member of the ASTM Board of Directors from 1954 to 1957. He is an active member of the Philadelphia District Council (vice-chairman, 1948-1952). Mr. Albert was first chairman of the study committee that investigated and recommended the purchase of the present ASTM headquarters building 15 years ago and, for the past three years, has been chairman of the Special Headquarters Building Expansion Committee.

Mr. Albert is a founder member of the Delaware Valley Section, Technical Association of the Pulp and Paper Industry, and in recognition of his work the section instituted an Edward

J. Albert Award, given annually to the author of the outstanding paper presented at the Society's May meeting. He is past-president of the Scientific Apparatus Makers Association, which honored him with the SAMA Award for a lifetime of accomplishments and service—service to the industry; service to science; service to the nation. This award has been made only ten times in the history of the association. He also is a fellow of the American Association for the Advancement of Science. Some other of his activities include membership in the Instrument Society of America, American Institute of Mining, Metallurgical and Petroleum Engineers, American Petroleum Inst., and American Society for Quality Control.



Simon Collier, formerly director of quality control, Johns-Manville Corp., New York, N. Y., is now a quality control consultant on asbestos fiber

and its products. A native of Salem, Mass., Mr. Collier was graduated from Worcester Polytechnic Inst. in 1916 with a B.S. degree in chemistry. Upon graduation he became associated with Boston Belting Co. for several years as a chemist, then was associated with the National Bureau of Standards as a chemist in charge of rubber work. Mr. Collier joined Johns-Manville in 1923 as manager of the Inspection and Control Dept. and became successively staff manager of that department then director of quality control, continuing in the latter position until his retirement in 1959. Since that time he has acted as quality control consultant on asbestos fiber and its products.

Mr. Collier has for years been a foremost proponent of the statistical approach to quality control and has long recognized the need for quality consciousness both at the operating level and in top management. Because of this, he has felt that an educational approach is imperative, and his activities and efforts among industries and engineering institutes have been directed along these lines.

Mr. Collier joined ASTM in 1926. He was a member of the Board of Directors of the Society from 1948 to 1951 and received the Society's Award of Merit in 1956. He is active on several committees, including E-11 on Quality Control of Materials, of which he is currently chairman. He is also chairman of the rubber committee, secretary of the asbestos-cement products committee, and a member of the committees on carbon black and on nomenclature and definitions.

Mr. Collier is a member of the Chemists' Club of New York City, the American Institute of Chemists, the American Chemical Society, and the American Society for Quality Control, of which he is a founding member.



Theo. Parker Dresser, Jr., is president and chief engineer of Abbot H. Hanks, Inc., San Francisco, Calif. A native of Medford, Mass., he studied

mining engineering at the University of California, Berkeley. For several years he was employed in engineering projects in connection with inspection and testing on road, tunnel, wharf, and building construction. He was appointed chief engineer of Abbot A.

Honorary Members

Hanks in 1917, president in 1961, and has been continuously connected with inspection, testing, research, and consulting in the field of materials and related construction problems. He has directed work on concrete and earth dams, concrete and steel structures, foundation investigations, corrosion problems, and specification writing, in addition to general investigational services.

He has been the representative of Abbot A. Hanks in ASTM since 1917, is a member of the cement committee and former member of the soils committee. Mr. Dresser was a member of the Society's Board of Directors from 1948 to 1951 and a member of the Administrative Committee on District Activities from 1945 to 1956. He is a founder member of the Northern California District Council, (secretary, 1931 to 1944) and has been an ardent worker in its administration since it was organized in 1930. Mr. Dresser received the Society's Award of Merit in 1957.

He is a past-president of the San Francisco Section of the American Society of Civil Engineers and a past-president of the Association of California Testing and Inspection Laboratories. His other society affiliations include the Structural Engineers' Association of Northern California, Consulting Engineers Association of California, American Concrete Inst., National Association of Corrosion Engineers, and the Construction Specifications Inst. He is a member of the Engineers' Club of San Francisco and Commonwealth Club of California.



Stanton Walker is director of engineering of both the National Sand and Gravel Assn. and the National Ready Mixed Concrete Assn., both in

Washington, D. C. Mr. Walker is a native of Vevay, Ind., and a graduate of the University of Illinois, from which he received his B.S. degree in 1917. He joined the staff of the Portland Cement Assn. in 1917 as a research engineer in the Structural Materials Research Laboratories. He has been director of engineering of NSGA since 1926 and of NRMCA since 1930. He is also director of the Joint Research Foun-

dation of NSGA and NRMCA at the University of Maryland.

A recognized authority on concrete and concrete aggregates, Mr. Walker has been a member of ASTM since 1920. He has served actively on Society committees concerned with cement, concrete, lime, mortars, and road and paving materials. He is an Honorary Member of Committee C-12 on Mortars for Unit Masonry and was the recipient of the Sanford E. Thompson Award established by the concrete committee. He received the ASTM Award of Merit in 1951 and the Frank E. Richart Award in 1957. From 1940 to 1942 he was a member of the ASTM Executive Committee and a member of the Board of Directors from 1951 to 1954.

Mr. Walker is past-president and Honorary Member of the American Concrete Inst. and received its Henry C. Turner Gold Medal in 1961. He is past-chairman and member of the Executive Committee of the Highway Research Board and received the Board's Roy W. Crum Award in 1956. He is a member of the American Institute of Mining, Metallurgical and Petroleum Engineers, and in 1961 he was made a Life Member of the American Society for Civil Engineers. Mr. Walker is the author of numerous technical papers dealing with research in concrete and mineral aggregates.



William A. Zinzow is former assistant director of development, Bakelite Co. A native of Ripon, Wis., Mr. Zinzow took his A.B. at Ripon College in 1915 and his M.S. at the University of Pittsburgh in 1925. From 1915 to

1926 he was successively an instructor at the high school in Wassau, Wis., University of Pittsburgh, and Muskingum College, excepting the year 1920 when he was with the Research Dept. of the Westinghouse Electric Corp. Mr. Zinzow joined the technical staff of the Bakelite Co. in 1926, later became chief physicist, and was assistant director of development when he retired from Bakelite in 1955. He served as a consultant with the National Academy of Sciences from 1955 to 1959 as a staff member of the Materials Advisory Board.

An authority in the fields of electrical insulating materials and plastics, Mr. Zinzow began his ASTM activities in 1934 as a member of Committee D-9 on Electrical Insulating Materials and became a member of the Society in 1936. He was vice-chairman of Committee D-9 from 1952 to 1954, secretary from 1942 to 1948, and is now an Honorary Member of the committee. He has been a member of the plastics committee since 1937 and was first vice-chairman from 1952 to 1954. He was also active on Committee E-1 on Methods of Testing and on the rubber committee.

Mr. Zinzow served as a member of the ASTM Board of Directors from 1945 to 1948 and was a member of the Administrative Committee on Standards from 1950 to 1956. He received the Society's Award of Merit in 1955.

Mr. Zinzow was active on Technical Committee 61 on Plastics of the International Organization for Standardization and represented the American group at New York and Turin, Italy in 1952. He was a member of the ASA-ASTM Joint Standards Board and chairman-leader of the ASA Working Group on Thermal Properties. He was also a member of the American Physical Society, the American Ordnance Assn., and the American Optical Society.

The Sun—Source of Energy and Hope

SCIENCE and technology and the destructiveness of weapons of war have advanced so rapidly in the last 15 years that either the nations of the world must learn to live together or they will all die together. Fortunately, advances in communication and travel have been rapid, too, so that we can be close friends with all nations. Our country with its highly developed science and technology and its humanitarian principles has a heavy obligation to help the nonindustrialized countries. It is not sufficient for our colleges and universities to teach the accumulated knowledge of the past and to train citizens for our own country.

It is their duty to develop leaders with vision and to stress the international character of the present-day world.

One of the ways we can help other countries and relieve potential war tensions is to provide improved technical and industrial opportunities for the economically underdeveloped countries. The greatest need is for new sources of energy with which the people can increase their productivity. In solar energy lies great hope. It is an abundant, neglected, natural resource already distributed over all these countries. Theoretically it can fulfill many of the needs, but much research is necessary to make it practical and economic.

Farrington Daniels,
Utilization of Solar Energy,
1960 Edgar Marburg Lecture

Awards of Merit

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Seventeen leaders in the field of engineering materials—men who have rendered outstanding service to ASTM, particularly in its technical committee work—were presented with Awards of Merit at the Awards Luncheon on Wednesday, June 28.

Each technical committee may suggest one candidate for this award annually, and the Award Committee may select nominees from other areas of the Society's work as well. While each of the following award winners was honored for intensive work in a specific technology, each has contributed in many ways to the over-all worth of the Society.

To John J. Allen in recognition of long and effective services to the Society in technical committees, district and administrative activities, and especially for work in Committee D-11 on Rubber and Rubber-Like Materials.



John J. Allen, General Research Management Staff, The Firestone Tire and Rubber Co., Akron, Ohio, has represented Firestone in ASTM since

1931 and has been a member of Committee D-11 on Rubber and Rubber-Like Materials since that time. Active on many subcommittees of Committee D-11, he is currently editorial chairman and finance chairman of Subcommittee III on Tests of Thread Rubber. He represents ASTM on the SAE-ASTM Joint Committee on Automotive Rubber and is a member of the American Group of ISO/TC 45. Mr. Allen was active in both the Cleveland and New England District Councils, and the Ordnance Advisory Committee. He was also a member of the ASTM Board of Directors from 1939 to 1941.

To Frank E. Clarke in recognition of outstanding leadership and significant contributions to the activities of Committee D-19 on Industrial Water.



Frank E. Clarke, U. S. Geological Survey, Quality of Water Branch, Washington, D. C., became active in ASTM in 1942. He was chairman

of Committee D-19 on Industrial

Water for three years and is currently vice-chairman and a member of its Advisory Committee. He has also served on many subcommittees and was chairman of Subcommittee IV on Methods of Analysis of Industrial Water for nine years. Other ASTM activities include membership in several subcommittees of Committee E-1 on Methods of Testing, ASTM representative on the Standards Methods Committee of the American Public Health Assn., and also the Joint Committee for Uniformity of Methods for Examination of Water.

To Thomas E. Eagan in recognition of outstanding contributions to the field of ferrous metals, particularly in Committee A-3 on Cast Iron, and for administrative support as committee secretary and chairman.



Thomas E. Eagan, chief research metallurgist, The Cooper - Bessemer Corp., Grove City, Pa., became a member of ASTM in 1939. He has

been active on Committee A-3 on Cast Iron for twenty years, serving as secretary from 1956 to 1958 and chairman from 1958 to 1960. He has served on many of its subcommittees and is responsible for the successful development of many of its specifications. Mr. Eagan is also a member of Committee A-1 on Steel and participates in the work of its subcommittees. He is the author of many papers on the subjects of gray and nodular graphite irons.

To David F. Gould in recognition of his work in the promotion of knowledge of the materials of engineering and the standardization of specifications and methods of testing, especially as a member and officer of Com-

mittee D-16 on Industrial Aromatic Hydrocarbons and Related Materials.



David F. Gould, consultant, Information - Industry, Philadelphia, Pa., became active in ASTM in 1926. He is a charter member of

Committee D-16 on Industrial Aromatic Hydrocarbons and Related Materials. For 12 years he was chairman of the main committee and also of its Advisory Committee. He was a member of Committee D-1 on Paint, Varnish, Lacquer and Related Products and was secretary for nine years of Subcommittee XXV on Lacquers.

To Russell B. Gunia in recognition of his efforts in the establishment and promotion of workable specifications, particularly in Committee A-10 on Iron-Chromium, Iron-Chromium Nickel and Related Alloys.



Russell B. Gunia, manager, stainless-steel metallurgy, United States Steel Corp., Pittsburgh, Pa., joined ASTM in 1943. He is a

member of Committee A-10 on Iron-Chromium, Iron-Chromium-Nickel and Related Alloys, has been active on many of its subcommittees, and is currently chairman of Subcommittee VIII on Specifications for Wrought Products. He has made contributions to many of the present ASTM stainless-steel specifications.

Awards of Merit

To Francis M. Howell in recognition of long and constructive participation in the work of Committee B-7 on Light Metals and Alloys, Cast and Wrought, and for services in administrative and district work.



Francis M. Howell, chief, Mechanical Testing Div., Alcoa Research Laboratories (retired), New Kensington, Pa., has been a member of

ASTM since 1919. He has served on Committee B-7 on Light Metals and Alloys since its formation in 1929 and has participated in the work of many of its subcommittees. Other technical committee activities include membership on Committee E-9 on Fatigue and several subcommittees of Committee E-1 on Methods of Testing. He served on Committees B-6 on Die-Cast Metals and Alloys for 13 years and E-8 on Nomenclature and Definitions for 10 years. Mr. Howell was instrumental in organizing the Pittsburgh District Council and served as its first secretary and later as chairman. He was a member of the Committee on Papers and Publications, Award Committee, and Long Range Planning Study Committee on Publications.

To Richard S. Hunter in recognition of significant contributions to the evaluation of optical and appearance properties of materials, particularly in Committee E-12 on Appearance.



Richard S. Hunter, president, Hunter Associates Laboratory, McLean, Va., has been a member of ASTM since 1946. He has made significant

contributions to the evaluation of optical and appearance properties of materials in numerous ASTM committees. A member of Committee E-12 on Appearance for 13 years, he served as secretary for six years and is chairman of Subcommittee 6 on Geometric Terminology.

To James H. Lansing in recognition of long and devoted participation in the field of cast metals, notably in Committee A-7 on Malleable Iron Castings of which he is serving his 14th year as secretary, and for administrative and district activities.



James H. Lansing, executive secretary, Ductile Iron Society, Cleveland, Ohio, has been a member of Committee A-7 on Malleable Iron Castings

since 1940 and a member of the Society since 1958. He has been secretary of Committee A-7 since 1948 and is active on many of its subcommittees, being currently chairman of Subcommittee III on Air Furnace, Electric, and Multiplex Malleable Iron. He is also active on Committees A-3 on Cast Iron, B-8 on Electrodeposited Metallic Coatings and Related Finishes, and E-1 on Methods of Testing. He was a member of the Administrative Committee on District Activities and is currently a member of the Cleveland District Council, having served as secretary for three years, vice-chairman for one year, and chairman from 1958 to 1960.

To William Lerch in recognition of outstanding service and contributions to ASTM research and standards work, especially in Committee C-9 on Concrete and Concrete Aggregates.



William Lerch, consultant, cement and concrete, Park Ridge, Ill., became a member of ASTM in 1947 and has been active since then on

Committee C-9 on Concrete Aggregates and its subcommittees. For eight years he was chairman of C-9 Subcommittee IIb, Methods of Testing for Volume Changes of Concrete and Concrete Aggregates. His other ASTM activities include membership on Committees C-1 on Cement (chairman of the Subcommittee on Sulfate Resistance), C-12 on Mortars for Unit Masonry (chairman of Subcommittee II on Research and Methods of Test), and C-17 on Asbestos-Cement Products (chairman of Subcommittee II on Research). Mr. Lerch has also served on the Administrative Committee on Papers and Publications. In 1947 and again in 1952 he received the Society's Sanford E. Thompson Award.

To Robert R. Litehiser in recognition of long and notable work in the field of cement, of extensive contributions to many technical committees, particularly C-1 on Cement, and for administrative service.



Robert R. Litehiser, engineer of tests, Ohio State Highway Testing Laboratory, Columbus, Ohio, joined ASTM in 1930 and has been a

member of Committee C-1 on Cement for 24 years. He has been chairman of the committee since 1951 and is also chairman of its Advisory Committee. Subcommittee activities included the Sponsoring Committee on Portland Cement, of which he was chairman for several years, and the Subcommittee on the Cement and Concrete Reference Laboratory. Mr. Litehiser is also a member of Committees C-3 on Chemical-Resistant Mortars, D-4 on Road and Paving Materials, C-9 on Concrete and Concrete Aggregates (secretary for 10 years), A-1 on Steel, C-13 on Concrete Pipe (current chairman), D-18 on Soils for Engineering Purposes, and C-15 on Manufactured Masonry Units. He was a member of the Board of Directors from 1956 to 1959, and of the Ohio Valley District Council from 1956 to 1959.

To Percy L. Rogers in recognition of many years of constructive support and leadership in the work of Committees C-7 on Lime and C-12 on Mortars for Unit Masonry, and especially for numerous researches relating to the development of methods of test for the efflorescence potential of masonry mortars.



Percy L. Rogers, vice-president, research, River-ton Lime and Stone Co., Riverton, Va., has been a member of Committees C-7

on Lime and C-12 on Mortars for Unit masonry for 23 years and a Society member since 1957. He is second vice-chairman of Committee C-12 and is on the Advisory Committee and chairman of Subcommittee II, Research and Methods of Test. He is active in many subcommittees of the lime committee and is currently chairman of Subcommittee X on Hydraulic Lime. Other committee activities include C-1 on Cement and C-16 on Thermal Insulating Materials. He is also a member of the Washington, D. C., District Council. For a number of years, Mr. Rogers has had primary responsibility for conducting an extensive research program for Committee C-12 relating to meas-

urement of efflorescence on brick and masonry structures.

To Anthony M. Schwarz in recognition of outstanding service in the development of test methods and processes in Committee D-12 on Soaps and Other Detergents.



Anthony M. Schwarz, manager, Industrial Chemical Div., Harris Research Laboratories, Inc., Washington, D. C., has been a member of ASTM and

of Committee D-12 on Soaps and Other Detergents since 1952. In 1960 he received the Committee D-12 award in recognition of his contributions and service in the field of detergents. He is a member and past-chairman of D-12 Subcommittee T-5 on Physical Testing, a member of the Advisory Subcommittee G-2 on Nomenclature and Definitions. He is senior co-author of two monographs, *Surface Active Agents and Detergents*, which have been widely acclaimed as the most authoritative and complete texts in the field.

To Arthur G. Scroggie in recognition of many years of outstanding contributions and support of activities in Committee D-13 on Textile Materials.



Arthur G. Scroggie, research manager, Textile Research Laboratory (retired), E. I. du Pont de Nemours and Co., Inc., Experimental Sta-

tion, Wilmington, Del., has been a member of ASTM since 1930. He was a member of Committee D-13 on Textile Materials for 30 years, was the committee's first vice-chairman, and served on many of its subcommittees. He was also active on Committees D-12 on Soaps and Other Detergents, E-8 on Nomenclature and Definitions, and E-11 on Quality Control of Materials. He represents ASTM on ASA Sectional Committee L14 on Textile Test Methods, L22 on Textiles, and L23 USA Committee for ISO Committee 38 on Textiles. In recognition of his outstanding achievements in the field of textile fiber utilization he received the ASTM Harold DeWitt Smith Award in 1956. Dr. Scroggie was a key member of the American Group to ISO/TC 38 meetings in Europe in 1948, 1951, 1952, 1956 and 1960.

To Hubert R. Snoke in recognition of long and active service on Committee D-6 on Bituminous Materials for Roofing, Waterproofing, and Related Building or Industrial Uses, Committee C-17 on Asbestos-Cement Products, and for administrative service.



Hubert R. Snoke, Chevy Chase, Md., assistant chief, Building Technology Div., and chief, Floor, Roof and Wall Covering Section (retired),

National Bureau of Standards, has been a member of ASTM and of Committee D-8 on Bituminous Materials for Roofing, Waterproofing, and Related Building or Industrial Uses since 1929. He has been chairman of Committee D-8 since 1952 and has served on many of its subcommittees. He represents Committee D-8 in Committees D-6 on Paper and Paper Products and E-5 on Fire Tests of Materials and Construction. He served as chairman of Committee C-17 on Asbestos-Cement Products and is now an Honorary Member of that committee. Dr. Snoke is a member of the Sectional Committee on Magnesium Oxide Chloride Cement Flooring ASA Project A88, and is serving on the ASTM Administrative Committee on Simulated Service Testing.

To John W. Whittemore in recognition of valued contributions to the work of Committee C-15 on Manufactured Masonry Units and for administrative support as chairman of the committee.



John W. Whittemore, dean of engineering, Engineering Experiment Station, Virginia Polytechnic Inst., Blacksburg, Va., has represented the Virginia Polytechnic Inst. in ASTM since

1930. He has been active on Committees C-3 on Chemical-Resistant Mortars, C-12 on Mortars for Unit Masonry, and C-15 on Manufactured Masonry Units. He was secretary of Committee C-15 from 1937 to 1948 and has been chairman since 1948. He also represented the American Ceramic Soc. on Committee C-8 on Refractories. He has been a member of many subcommittees and is serving as chairman of Subcommittees I and VI of Committee C-15. He was a member of the Washington, D. C., District Council for four years.

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To Lyman W. Wood in recognition of active participation in the work of ASTM committees, especially Committee D-7 on Wood, and in the ASTM Wood Pole Research Program.



Lyman W. Wood, civil engineer, U. S. Forest Products Laboratory, Madison, Wis., joined ASTM in 1947 and since that time has been a member

of Committee D-7 on Wood, serving for two years as vice-chairman. He is an active member of Committees E-6 on Methods of Testing Building Constructions and E-8 on Nomenclature and Definitions and represents Committee D-7 on Committee E-12 on Appearance. Mr. Wood is one of two men in charge of the \$300,000 ASTM Wood Pole Research Program and was a co-author of the final technical report, published in 1960. He was also a member of the Administrative Committee on Papers and Publications for six years.

To John S. Worth in recognition of sustaining and significant contributions to the development of standards, especially in Committee A-1 on Steel.



John S. Worth, metallurgical engineer, Bethlehem Steel Company, Inc., Bethlehem, Pa., has been a member of ASTM and of Committee A-1

on Steel since 1941. He was secretary of Committee A-1 for four years, and is a member of many of its subcommittees. He is active in Committees A-5 on Corrosion of Iron and Steel; A-10 on Iron-Chromium, Iron-Chromium-Nickel and Related Alloys; and the ASTM-ASME Joint Committee on Effect of Temperature on the Properties of Metals. Mr. Worth is a recognized authority in the metallurgical field and has devoted much effort to the field of bolting steels, especially for sub-normal and elevated temperature service.

Medals and Awards

Research in Engineering Materials

CHARLES B. DUDLEY MEDAL

This medal was established by voluntary subscriptions from the members as a means of stimulating research in materials and of recognizing meritorious contribution to its publications, at the same time commemorating the first president of the Society whose inspiring leadership has had a profound influence on its development.

● 1961 award to **G. B. Espey, M. H. Jones, and W. F. Brown** for their paper, "The Sharp Edge Notch Tensile Strength of Several High Strength Steel Sheet Alloys," which was presented at the Society's 62nd Annual Meeting in Atlantic City, N. J., and subsequently published in the *ASTM Proceedings*, Vol. 59 (1959).



George B. Espey received his B.S. degree from Grove City College in 1939 and his M.S. degree in metallurgical engineering from Case Institute of Technology in 1941. He remained at Case Institute for several years as a research assistant and extended his graduate thesis under the sponsorship of the Frankford Arsenal. In 1943 he was a tool specialist for the Shell and Bomb Forging Committee of The American Society of Mechanical Engineers. From 1943 to 1946, Mr. Espey was a senior research engineer, Case Institute, and between 1946 and 1953 he was laboratory director, Metals Research Associates, Inc. He joined the National Aeronautics and Space Administration in 1953 to aid in the development and fabrication of brittle dispersions and nuclear fuel elements; in 1958 he was appointed to his present position as research engineer, Strength of Materials Branch, where attentions center on materials for such applications as rocket casings, supersonic aircraft, and spacecraft. He has been author of numerous scientific reports, and received formal commendation from the wartime chiefs of the U. S. Office of Scientific Research and Development for work on high-strength aluminum alloys. He is a member of the American Society for Metals and Sigma Xi.

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Melvin H. Jones, a native of Cleveland, Ohio, attended Case Institute of Technology. In 1941 he was associated with the Metals Research Laboratory, Case Institute, as a research assistant on research programs including development of steel cartridge cases, formability of aluminum aircraft alloys, and evaluation of secondary aluminum casting alloys. He joined the Lewis Research Center, National Aeronautics and Space Administration, in 1948, and has been in his present position of research engineer, Strength of Materials Branch, since 1959.

Mr. Jones's research efforts at NASA have been in the areas of tensile properties of heat-resistant alloys, creep and rupture behavior as influenced by high stress concentrations, and evaluation of high-strength sheet alloys with sharp-edge-notch tensile strength. He has been coauthor of a number of papers concerning metal flow and fracture. He is a member of the American Society for Metals and the Society for Experimental Stress Analysis.

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William F. Brown, a native of Lakewood, Ohio, attended undergraduate and graduate school at Case Institute of Technology in the Department of Metallurgical Engineering from 1941 to 1946. He was a research assistant, Metallurgical Engineering Research Laboratory, Case Institute, for three years. In 1948 he joined the Lewis Research Center, National Aeronautics and Space Administration, as a research metallurgist in the Materials and Thermodynamics Div.; in 1959 he was appointed to his present position as chief, Strength and Materials Branch.

Mr. Brown has specialized in the flow and fracture of metals as influenced by loading conditions and metallurgical factors and has published approximately

50 papers in these fields. Most recently he has been interested in the influence of high stress concentrations on the properties of high-strength sheet alloys at cryogenic and moderately elevated temperatures.

Mr. Brown has been a member of ASTM since 1949. He is a member of the Panel on Structural Materials for Aircraft and Missiles of the ASTM-ASME Joint Committee on Effect of Temperature on Properties of Metals, and a member of the ASTM Special Committee on Fracture Testing of High Strength Materials.

Activities outside of ASTM include chairman, Brittle Fracture Subcommittee, and member of the Properties of Metals Committee of The American Society of Mechanical Engineers; member of the NASA Special Committee on Materials Research for Supersonic Transports; Sigma Xi; and an associate member of the British Institute of Metals. He is also consulting editor to Syracuse University of *Air Weapons Materials Application Handbook*, and technical program consultant to the U. S. Office of Ordnance Research.

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Testing of Soils

C. A. HOGENTOGLER AWARD

This award was established by Committee D-18 on Soils to commemorate its first chairman, to be given to authors of outstanding papers on soils presented at a meeting of the Society.

● 1961 award to **Carl B. Crawford** for his paper, "The Influence of Rate of Strain on Effective Stresses in Sensitive Clay," which was presented at the Society's 62nd Annual Meeting in Atlantic City, N. J., and appears in the Society's publication *STP 254*.



Carl B. Crawford, a native of Canada, received his B.S. degree in civil engineering from Queen's University in 1949, and his M.S. degree in

civil engineering from Northwestern University in 1950. In 1956 and 1957 he studied at the Imperial College of the University of London.

Mr. Crawford represents the National Research Council of Canada on ASTM Committee D-18 on Soils for Engineering Purposes and is first vice-chairman of the committee; he is

chairman of Subcommittee R on Research, and a member of R-2 on Sampling and Related Field Testing for Soil Investigation. He is a member of the Engineering Institute of Canada and the Professional Engineers of Ontario.

Corrosion Research and Tests

SAM TOUR AWARD

The purpose of this award is to encourage research on the improvement and evaluation of corrosion testing methods and to stimulate the preparation of technical papers in this field.

- 1961 award to **A. Kenneth Graham** and **H. L. Pinkerton** for their paper, "Standardizing the Preparation of Electrodeposits on Test Panels for Corrosion Testing," which was published in the *ASTM Proceedings*, Vol. 59 (1959).



A. Kenneth Graham is a native of Philadelphia, Pa. He received his B.S. degree in 1919, Ch.E. degree in 1923, M.S. degree in 1924, and Ph.D. de-

gree in electrochemistry in 1927 from the University of Pennsylvania, where he taught chemistry and chemical engineering for 14 years. He served as consultant to the War Production Board and the Manhattan Project during World War II. Dr. Graham has been president of Graham, Savage & Associates, Inc. since it was formed in 1944.

Dr. Graham has been a member of ASTM and of Committee B-8 on Electro-deposited Metallic Coatings and Related Finishes since 1941, and is active on many subcommittees of B-8. He has published many technical articles and served as editor-in-chief of the *Electroplating Engineering Handbook*. He holds several patents and is a member and past-executive secretary of the American Electroplaters' Society. He was a three-time winner of the Society's Gold Medal for technical publications and a recipient of the AES Scientific Award and the Second William Blum Lecture. His other Society affiliations include the American Chemical Society, the American Electroplater's Society, the Electrochemical Society, American Institute of Chemical Engineers, Institute of Metal Finishing, and Association of Consulting Chemists and Chemical Engineers.



Henry L. Pinkerton is a native of Dayton, Ohio and received his M.S. degree in chemical engineering from the University of Pennsylvania in

1932. He was affiliated with the Philco Corp. for a number of years as a plating engineer and was later in charge of metal finishing. For several years during World War II, Mr. Pinkerton was research director for the New England Lime Company's magnesium plant. Since 1944 he has been associated with Graham, Savage & Associates as a chemical engineer.

Mr. Pinkerton has published a number of technical articles and served as assistant editor of the *Electroplating Engineering Handbook*. He is a licensed professional engineer in Pennsylvania. He is a member of the Electrochemical Society, the American Electroplater's Society, Tau Beta Pi, Alpha Chi Sigma, Sigma Xi, and Delta Chi.

Concrete and Its Aggregates

SANFORD E. THOMPSON AWARD

This award was established by Committee C-9 on Concrete and Concrete Aggregates to commemorate its first chairman, to be given to authors of papers of outstanding merit in that field, to stimulate research and extension of knowledge, and to recognize meritorious efforts.

- 1961 award to **L. Pepper** and **Bryant Mather** for their paper, "Effectiveness of Mineral Admixtures in Preventing Excessive Expansion of Concrete Due to Alkali-Aggregate Reaction," which was presented at the 62nd Annual Meeting of the Society in Atlantic City, N. J., and subsequently published in the *ASTM Proceedings*, Vol. 59 (1959).

Leonard Pepper, a native of New York City, received his degree in chemical engineering from the College of the City of New York in 1940. He was metal inspector, Heat Treating Department, New York Ordnance District in 1941 and 1942; then roving engineer, Signal Corps Equipment, Philadelphia Signal Corps District for five years. In 1947 he joined the Waterways Experiment Station as a chemist and has been chief of the Chemistry Section since 1951.

Mr. Pepper is a consulting member of ASTM Subcommittee III on Specifi-

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cations and Test Methods of Committee C-9 on Concrete and Concrete Aggregates.

The Waterways Experiment Station has published a number of Mr. Pepper's technical reports and memoranda including "Use of Epoxy Resin," "Statistical Studies of Curing Compounds," "Plastic Waterstop Testing," "Determination of SO₃ in Soils," "Heat Studies of Portland and Natural Cements," and "Alkali-Aggregate Reaction."



Bryant Mather, a native of Baltimore, Md., was graduated from Baltimore City College in 1934, and received an A.B. in geology from the Johns Hop-

kins University in 1936. He was a graduate student in geology from 1936 to 1938 and from 1940 to 1941 at the Johns Hopkins University. He also did graduate work in economics at the American University in 1938 and 1939.

He was assistant curator in charge of mineralogy at the Chicago Museum of Natural History from 1939 to 1941 and has been associated with concrete research for the Corps of Engineers since 1941, first as a geologist, and later as a civil engineer.

Mr. Mather has been a member of ASTM since 1944, of Committee C-9 on Concrete and Concrete Aggregates since 1946, and of Committee C-1 on Cement since 1954. He has been chairman of Subcommittees II-b on Chemical Reactions and III-h on Admixtures of Committee C-9 and has been secretary of the main committee since 1951. He is a member of a number of subcommittees and working committees of Committees C-9 and C-1 and was a member of the Committee C-1 Sponsoring Committee on Blended Cements.

From 1953 to 1957 he was a member of the ASTM Dudley Medal Committee and is a member of the Society's Long-Range Planning Committee on Technical Committee Activities, and of the Southeast District Council. He received the ASTM Award of Merit in 1959.

Mr. Mather is a member of the American Concrete Inst., serving on its Board of Direction, a number of its technical committees, and its Technical

Medals and Awards

Activities Committee, of which he was formerly chairman. He is also a member of several committees of the Highway Research Board. His other memberships include the American Institute of Mining, Metallurgical and Petroleum Engineers, the Meteoritical Society, the U. S. Committee on Large Dams, the Mississippi Geological Society, and the Mississippi Academy of Sciences. He has been author or coauthor of numerous technical papers.

Test Methods and Apparatus

RICHARD L. TEMPLIN AWARD

The purpose of this award is to stimulate research in the development of testing methods and apparatus, to encourage the presentation to the Society of papers describing new and useful testing procedures and apparatus, and to recognize meritorious efforts of this kind.

● 1961 award to E. A. Neppiras for his paper, "Techniques and Equipment for Fatigue Testing at Very High Frequencies," published in the 1959 ASTM Proceedings.

E. A. Neppiras, a resident of Reigate, Surrey, England, is the first overseas author to receive an ASTM award. He was a Royal Scholar at the Imperial College, London, and was graduated with honors in physics in 1940. He is an associate of the Royal College of Science. From 1947 until recently he was employed as senior physicist at Mullard Research Laboratories, Salfords, Surrey, England. He is now chief ultrasonic physicist at Mullard Equipment Ltd.

Mr. Neppiras has done much pioneer research in the field of high-energy ultrasonics. He is the author of many scientific papers in this field, published in British scientific journals.



"When we can all take our minds off the struggle for a plentiful material existence, we shall then be able to look to the nobler ends which are within man's capacity and which must be his destiny."

A. A. BATES
(See p.555)



MARSHALL ACCEPTS TOOTHsome AWARD

At the height of the Awards Luncheon, toastmaster R. T. Kropf (left) pauses to recognize the nonstop activities of Executive Secretary T. A. Marshall, Jr., in behalf of a successful Annual Meeting. Ostensibly conferred by "Committee Z-99 on Useless Functions," the award was a tube of food-impregnated toothpaste for people with no time to eat between brushings. Mr. Marshall's response, for which there is already a heavy demand for reprints, was as follows:

"I'm not allowed to run the train or see how fast t'll go,
I ain't allowed to let off steam or make the whistle blow,
I cannot exercise control or even ring the bell.
But let the damn thing jump the track and see who catches hell!"

Three Authors Cited for Effective Presentations

IT IS EXPECTED that any scientist, by ability or training or both, should be able to communicate his thoughts to his fellows through effective presentation of the spoken word, as well as the written. Apart from maintaining the technical quality of all papers presented at meetings of the Society, the Administrative Committee on Papers and Publications is interested in improving the value of the technical sessions by improving the character of presentation of technical papers.

To foster improved communication and to make our technical sessions more interesting and thus more useful, each author is graded on the quality of his presentation. This procedure has been followed for the past six years and has proved very successful. Reporters were assigned this task at the 1960 Annual Meeting. Based upon their reports, the three outstanding

presentations for 1960 have been selected, and the following three authors are cited:

W. H. Johnson, formerly with Battelle Memorial Inst., now technical director of the Centrifugal Casting Div., Shenango Furnace Co., Dover, Ohio, for presentation of the paper on "Mechanical and Physical Properties of Five Copper-Base Alloys," by Messrs. Johnson and J. G. Kura.

J. H. Westbrook, General Electric Co. Research Laboratory, Schenectady, N. Y., for presentation of his paper on "An Improved Microhardness Tester for High-Temperature Use."

C. F. Brandenburg, Allison Div., General Motors Corp., for presentation of his paper on "Present Methods of Metallographic Specimen Preparation for Retention and Identification of Inclusions in Steel."



J. H. WESTBROOK



C. F. BRANDENBURG



W. H. JOHNSON

ASTM Student Prize Memberships

For several years now, many of the district councils of ASTM have awarded prize memberships to students at colleges and universities in their districts. Also, the Board of Directors has, in the past few years, granted similar awards in areas outside established districts. Why are these awards given? Are they serving their purpose?

The awards have a threefold purpose. First, they are granted to recognize the achievement of students in engineering and science who have shown superior scholastic ability and demonstrated interest in engineering materials and their evaluation. Secondly, by bringing these outstanding young men into the Society, it is hoped that they and the Society will mutually benefit. The student gains from his contact with the members of the Society an appreciation of the world of materials evaluation, materials research, and standardization. For its part, the Society gains an influx of new blood, of bright young students sincerely interested in materials, who, as they mature and move into industry, education, and government, will have an appreciation of the work of the Society. The third objective, and by no means the least, is to maintain a valuable channel of communication between the Society and the academic world.

Are these objectives being met? The following brief excerpts from the many hundreds of letters received from the faculty members of the various schools and from the students speak for themselves:

"... These Student Prize Awards are always coveted and appreciated by the students who receive them and also by those of us on the engineering faculty ..."

MERLE C. NUTT
Associate Professor of Engineering
Arizona State University

"... On behalf of the College of Engineering faculty, I wish to thank you and the officers of ASTM for making these student memberships available to our students. I trust that it will serve to increase student interest in the Society ..."

MARION L. SMITH
Associate Dean
The Ohio State University

"... May I express to your Society the appreciation of the University for these new awards, which we hope will be of real value in stimulating academic achievement on the part of our engineering students in this area ..."

H. H. SAUNDERSON
President
The University of Manitoba



Lee P. Thompson, dean of engineering, Arizona State University, presents ASTM Student Award certificates to Carl Suter, Richard Green, Fred Ayer, Robert Bankwitz, John Lee, Carroll Hopkins, and Donald Autore.

"... They appreciate very much this honor which has been given to them and they have asked me to thank you and the Western New York-Ontario District for this honor which has been bestowed upon them. I know that these young people will gain a great deal professionally by this early association with ASTM ..."

R. M. CAMPBELL
Chairman of Department
State University of New York

"... As winner of a complimentary Student Membership Award, I wish to express my sincere appreciation and gratitude to those responsible for this award. I look forward to a continuing membership in your Society, hoping, at some future time, I may be of some small service to it. ..."

HENRY N. EDAMURA
Toronto, Ontario

I would like to thank you and the members of your Society for making the recent ASTM Student Membership Prize Award possible. ... I do feel that this award has brought me in contact with a society that will be an asset and service to me ..."

JOHN R. POTTER
Syracuse, N. Y.

"... I thank you very much for your letter of March 15. I am deeply honored to receive a complimentary student membership in ASTM. I am sure that a membership in the Society will be very helpful to my studies and future career."

TU-LUNG WENG
University Park, Pa.

The Society is encouraged by such response to feel that the Student Membership Award Program has value and should be continued.

High-Limit Accidental Death and Dismemberment Coverage Added to ASTM Group Insurance Program

A NEW PLAN of high-limit accident insurance covering death, dismemberment, and permanent total disability was recently approved by the Society's Board of Directors as an addition to the ASTM Group Insurance Program.

This new plan will offer coverage to a maximum of \$200,000 in units of \$25,000 at an annual cost of 90 cents per \$1000 for members under 70. The cost for members over 70 will be \$1.35 per \$1000, with maximum coverage of \$100,000. Coverage up to \$25,000 will also be available to spouses of members.

During the charter enrollment period of 90 days, which ends Aug. 8, all members and their spouses under age 75 may apply.

There will be no health requirements for coverage of \$100,000 or less.

The new plan covers accidents around the clock, including accidents at home, at work, and on vacation, and is not confined merely to travel. Coverage is written by the Continental Casualty Co., which underwrites the other plans in the program.

A brochure containing full details of this new coverage was mailed to members in May. Questions regarding the coverage should be addressed to Administrator, ASTM Group Insurance Program, 1120 Connecticut Avenue N. W., Suite 920, Washington 6, D. C., rather than to Society Headquarters.

"Our government is committed to a policy of providing technical assistance to other countries, and particularly to what are called 'under-developed' countries. . . . Through its work on standards, the ASTM has made a unique contribution to the ability of this country to lend [such] assistance. . . ."

F. L. LAQUE
1960 Presidents' Address

Uruguay Meeting Sets Goals for Latin American Standardization

A PROGRAM of standardization to meet specific Latin American needs in ten important fields was developed during a meeting of the Pan American Standards Committee, held April 24-27, in Montevideo, Uruguay. The program, which grew out of a reorganization meeting of the Pan American Standards Committee, was attended by 33 delegates representing Argentina, Brazil, Chile, Colombia, Peru, the United States, Uruguay, and Venezuela.

In addition to more general projects on fundamental standards and conversion factors, the following ten types of materials were selected for standardization projects during the coming three years:

- iron and steel products
- construction materials
- electrical materials
- automotive and railroad materials
- textile fibers
- sugar and alcohol
- vegetable and animal fats and oils
- leather and tanning materials
- canned foods
- solid and liquid fuels

Marshall Urges U. S. Industry Support

Preparation of technical standards by PASC will be undertaken at once through technical committees which will bring together the outstanding engineers, scientists, and technologists of the different countries, experts in the products and materials for which standards are sought. Standards of ASTM, SAE, and other North American organizations are widely used in Latin America. It is expected that many of these will be adapted to Latin American needs. ASTM Executive Secretary Marshall, a member of the U. S. delegation, stated that the success of the PASC operation will depend on active participation by the industries that will benefit from the standardization activities. American firms doing business in Latin

America, he said, must give generous technical and financial support to the work of the PASC through their branches and representatives in the different Latin American countries. He suggested also that such firms should support and encourage the participation of their representatives in the activities of the national standards organizations of the countries in which they operate.

PASC Reorganized for Action

In its reorganization, the PASC adopted a new constitution to provide for more effective implementation of its activities. Alberto Sinay Neves of General Electric, S. A., and past-president of the Brazilian Standards

Association (ABNT) was elected president. John R. Townsend, head of the U. S. delegation, was elected vice-president; and Senora Ing. Beatriz Ghirelli de Ciaburri, director-general of the Argentine National Standards Organization (IRAM), was elected to serve as provisional general secretary until circumstances permit the employment of a permanent general secretary. The facilities of IRAM will be made available for the work of the PASC, although Rio de Janeiro was selected as temporary headquarters pending receipt of the necessary funds to establish a permanent headquarters. Paulo Sá, director of the Brazilian Standards Association (ABNT), was



THE UNITED STATES DELEGATION TO THE PASC MEETING IN MONTEVIDEO.

(Standing, left to right) A. T. McPherson, associate director, National Bureau of Standards; R. L. Kessler, chief engineer, Chrysler Argentina, S. A.; H. A. Hunnicutt, technical representative for Brazil of The International Nickel Co., Inc.; and B. J. Smith, chief engineer, Ford Motor Argentina, S. A. (Seated, left to right) T. A. Marshall, Jr., executive secretary, ASTM; J. R. Townsend, head of the delegation, special assistant, Department of Defense Research and Engineering; and Vice-Admiral G. F. Hussey, Jr., USN retired, managing director and secretary of the American Standards Assn., which represents the United States in PASC.



Dr. Neves, new PASC president, exchanges ideas with Senora de Ciaburri on operating details of the reorganized committee.

made honorary president for life in recognition of his long participation in Pan American standardization activities.

The need for active financial and technical support from American industries having Latin American plants and branches was also stressed by Dr. Townsend. He said that such firms will benefit from PASC standardization activities and that generous support should be given to the standards bodies, both U. S. and Latin American, engaged in the PASC reorganization. Dr. Townsend, a past-president of ASTM, is president of the American Standards Assn., which represents the United States in PASC.

Executive Secretary Briefed by ASTM Members in São Paulo

En route to the meeting in Montevideo, Mr. Marshall met with a dozen Society members for an informal dinner at the Automovel Club in São Paulo, Brazil, on April 22. During the dinner, Mr. Marshall had an opportunity to discuss the general



Dr. Townsend (facing camera) discusses progress of the PASC meeting with Carlos Hoerning, director of INDICTECNOR, the Chilean standards organization.

problems of standardization in Brazil and how ASTM could assist. Those present included: Horace A. Hunnicutt, The International Nickel Co. representative in São Paulo; W. M. Mazaraki, Plasticos Playnil S. A.; Eng. V. F. B. de Mello, Geotécnica S. A.; Eng. R. Gomido, Indústrias Químicas Electrocloro S. A.; Eng. A. A.

Arantes and Enga. Alice Kosuta of the Instituto de Pesquisas Tecnológicas; Eng. M. A. Amorim, Termomecânica São Paulo S. A.; Eng. Jayme Bulcão, Companhia Siderúrgica Nacional; Dave Langlands, Willys Overland do Brasil S. A.; Eng. A. Schmidt, Ford Motor do Brasil; Eng. Hans Lubert Westfallen, Exploração de Petróleo "União" Ltda.; and Eng. Antonio Luiz Salgueiro, Aço Solar-Ferragens S. A.

Of special interest was the growth of the automobile industry in Brazil and the necessity for the development of more and better standards, particularly in non-ferrous metals.



Three members of the United States delegation during a visit to one of the major plants of las Usinas Electricas y los Telefonos del Estado.



THE DINNER GROUP AT SÃO PAULO, PRIOR TO THE PASC MEETING IN MONTEVIDEO.

TECHNICAL COMMITTEE NOTES

Packaging

Committee D-10, under its new title of "Packaging," is now on the threshold of broader service to the packaging industry following some 47 years of service under the title of "Shipping Containers." The several projects being considered by the committee as possible areas of work include test methods for shelf-size packages including bags, permeability of packages, tests for large containers under shelf and racking loads, the nonskid properties of fiberboard containers, tests for metal fasteners in wooden boxes, and impact and other tests for carloading and bracing.

The development of test methods for tapes used in packaging has begun. A test in which taped boxes are inflated to failure and two tape holding-power tests are being investigated by ten laboratories.

Data from an exploratory study of a method to test creep properties of package cushioning materials were presented. Following a discussion of test temperatures and humidities to be included, a working draft of the method was accepted for interlaboratory study. Test samples are being prepared for distribution to cooperating laboratories.

The third interlaboratory study of the draft method used to evaluate the compatibility of packaging material with the packaging product was reported. Considerable variation indicated that further refinement of this method is in order, and members of the Advisory Committee on Corrosion have been asked to review this work.

The subcommittee on the revolving drum test (Method 782) will sponsor an interlaboratory test to determine whether all drums in use rank the destruction of prepared standard boxes in the same order in spite of their many variations. Upon completion of this study, if the results are satisfactory, the data will be submitted to the permanent ASTM research report file. The incline impact test subcommittee is in the process of standardizing existing test machines. Specific points of investigation are velocity measurement, dolly surfaces, backstop perpendicularity and rigidity, and floor mountings. The recommended practice to assist in predicting the dead load storage life of corrugated and solid fiberboard boxes is being prepared for presentation to the Society.

A number of persons interested in

high-frequency vibration testing of packages met to discuss the development of a vibration damping test for interior packaging materials. A task group on this subject has been formed, and all interested persons are urged to write Jack C. Lewis, senior supervisor, Boeing Airplane Co., Transport Div., Box 707, Renton, Wash.

Ceramics for Electronics

The Subcommittee on Nonmagnetic Materials of Committee C-25 has completed work on the determination of the complex dielectric constant of non-metallic magnetic materials at microwave frequencies. Methods for measuring ferrimagnetic resonance linewidth and gyromagnetic ratio of nonmetallic magnetic materials, magnetization of these materials, and a method for measuring coincident current of ferrite memory cores are being investigated.

Members of the committee contributed to a symposium on tension testing sponsored by the American Ceramic Society in Toronto April 26. Promising

approaches will be used to develop a standard tension test for ceramic materials. A compressive test is being studied to determine its value for testing the materials covered by the committee. Much interest in composites such as ceramic coatings on metals and ceramics impregnated with metals, has been expressed and possible test methods for these materials will be explored. Process control and electrical test methods for ferroelectrics and tests for their raw materials are being studied. The basic properties of semiconductors are being reviewed for possible standards, and possible areas of work on the problem of electroding and the properties of thin films are being investigated.

Nuclear Magnetic Resonance

The Society has recently undertaken work in the area of nuclear magnetic resonance (NMR) in a new subcommittee of Committee E-13 on Absorption Spectroscopy. Much interest in this relatively new technique has been evident. Early use of NMR methods was largely in research, partly because of the newness of the technique and partly because of the availability of only quite expensive and bulky apparatus. With more compact and less expensive apparatus now being made available, however, it is probable that wider use will be made of this technique.

ASTM MEETINGS

Date	Group	Place
Aug. 15-18	Joint ASTM-TAPPI Committee on Petroleum Wax	Montreal, P. Q. Queen Elizabeth
Aug. 19	Joint Committee on Leather, and Physical Testing Committee of International Union of Leather Chemists	Washington, D. C.
Sept. 5-6	Committee D-23 on Cellulose and Cellulose Derivatives	Chicago, Ill.
Sept. 11-12	Committee C-22 on Porcelain Enamel	Cleveland, Ohio (Sheraton-Cleveland)
Sept. 24-28	Committee D-2 on Petroleum Products and Lubricants	Detroit, Mich. (Statler)
Sept. 27-28	Committee C-21 on Ceramic White-ware and Related Products	Bedford Springs, Pa.
1962		
Feb. 5-9	Committee Week	Dallas, Tex. (Statler-Hilton)
June 24-29	Annual Meeting	New York, N. Y. (Statler)
Sept. 30-Oct. 5	Pacific Area Meeting	Los Angeles, Calif. (Statler-Hilton)
1963		
Feb. 4-8	Committee Week	Montreal, P. Q. (Queen Elizabeth)
June 23-28	Annual Meeting	Atlantic City, N. J. (Chalfonte-Haddon Hall)

TECHNICAL COMMITTEE OFFICERS



COMMITTEE D-4 ON ROAD AND PAVING MATERIALS

Left to right, standing: J. E. Gray, second vice-chairman, National Crushed Stone Assn., Inc.; J. L. Wilks, third vice-chairman, Emulsified Asphalt Refining Co.; D. W. Lewis, membership secretary, National Slag Assn.; seated: R. E. Bollen, chairman; A. B. Cornthwaite, past-chairman, Virginia Department of Highways; B. F. Kallas, general secretary, The Asphalt Inst.; missing: W. H. Goetz, first vice-chairman, Purdue University.



COMMITTEE C-15 ON MANUFACTURED MASONRY UNITS

Left to right: J. W. Whittemore, chairman, Virginia Polytechnic Inst.; J. A. Lee, second vice-chairman, Southern Brick and Tile Manufacturers Assn., Inc.; M. H. Allen, secretary, Structural Clay Products Research Foundation; missing: P. M. Woodworth, first vice-chairman, The Waylite Co.; H. T. Toennies, membership secretary, National Concrete Masonry Assn.



COMMITTEE E-18 ON SENSORY EVALUATION OF MATERIALS AND PRODUCTS

Left to right: Amos Turk, chairman, consultant; Mavis B. Carroll, secretary, General Foods Corp.; missing: H. L. Stier, vice-chairman, National Canners' Assn.

International Conference on Spectroscopy

WITH THE main purpose to promote interdisciplinary exchange across geographical boundaries, an International Conference on Spectroscopy will be held June 18-22, 1962, at the University of Maryland. The technical program will include X-ray, infrared, nuclear magnetic resonance, electron paramagnetic resonance, microwave, astrophysical, and mass spectroscopy as well as education in spectroscopy.

Deadline for titles and up to 300-word abstracts of papers to be submitted is Dec. 1, 1961. These and requests for more information should be addressed to: F. Scribner, chairman, International Spectroscopy Conference, National Bureau of Standards, Washington 25, D. C. Sponsor of the Conference is the Society for Applied Spectroscopy.

NSF Study Shows Growth of R&D on Nation's Campuses

ALMOST 70,000 OF the scientists and engineers at U. S. colleges and universities during 1958-44 per cent of the total—were engaged in research and development, a recent National Science Foundation survey shows. These scientists and engineers were employed as follows: in the life sciences, 47 per cent; physical sciences, 26 per cent; engineering sciences, 17 per cent; and social sciences, 10 per cent.

These findings are announced in *Reviews of Data on Research & Development*, No. 27, "Scientists and Engineers Engaged in Research and Development in Colleges and Universities, 1958," released May 25.

Between 1954 and 1958, separately budgeted or "earmarked" expenditures for research and development in the natural and social sciences in colleges and universities increased from \$410 million to \$736 million. The growth of these expenditures necessitated an increase in the number of scientists and engineers engaged in research and development.

To meet the need for additional manpower, universities have apparently allocated more faculty time rather than increase the number of faculty engaged in R&D. The number of faculty engaged in R&D rose by only 3 per cent from 1954 to 1958, while the number of faculty members engaged full-time in R&D rose from about 7000 to 10,400. Of the faculty engaged in R&D, 32 per cent were engaged full-time in 1958 compared to 22 per cent in 1954.

Conducted for the National Science Foundation by the Department of Health, Education, and Welfare, Office

of Education, the survey obtained data by means of questionnaires mailed to 1916 independent and autonomous institutions of higher education in the United States.

Copies of the publication may be obtained from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. for 10 cents.

NEW ASTM PUBLICATIONS

1961 List of ASTM Publications Now Available

The 62-page list of ASTM publications for 1961 is now available. This list, which has been mailed to all members, describes the symposiums, manuals, special publications, indexes, compilation of standards, charts, reference photographs, and reports published by the Society through the years. More than 300 items are fully described, 40 of which are new and not previously listed.

The publications are arranged conveniently by title and subject. A convenient order blank is included. The list may be obtained free for the asking from Society Headquarters.

Symposium on Current Research on Motor Gasoline Which May Affect Future Specifications

STP 298, 109 pages, hard cover, price \$3.00, to members \$2.40.

THIS COMPREHENSIVE symposium volume presents an up-to-date picture of trends in the characteristics and properties of motor gasoline which may be reflected in future specifications.

The objectives of this symposium, held last February under the sponsorship of the gasoline committee of Committee D-2 on Petroleum Products and Lubricants, were: (1) to identify those product quality areas in which development is active, (2) to indicate

requirements for improved (or new) referee and developmental procedures, (3) to point out areas wherein product specifications may be affected, and (4) to serve as a forum for an up-to-date appraisal.

Of the nine papers, four are concerned primarily with the combustion characteristics and properties of motor gasoline, four others relate in some way to composition, and one is devoted to the other great variable in the automotive use of petroleum products, namely, the engine. The symposium concludes with an excellent summary and an objective appraisal of where we are and where we may be headed.

From the point of view of the engine manufacturer, the fuel properties that are most in need of attention are: (1) volatility; (2) combustion, including knock resistance; and (3) dirt, including stability.

There is general agreement that the existing standard methods for volatility are adequate. One author, however, points out some of the problems of evaluating additives as carburetor-icing preventives. It appears that no great changes in volatility characteristics are likely in the immediate future either in specifications or as regards the standard methods of test.

As to fuel contamination, it appears that adventitious dirt cannot be wholly controlled at the point of manufacture of the fuel. To be effective, samples would have to be taken at point of use. This quality feature is being subjected to wide and intense developmental effort, however, and as real progress is

made it will be appropriately reflected in revision of specifications.

As regards combustion characteristics or octane number determination, it is considered important to differentiate between referee (or control) test methods and evaluations for product and process improvement. It is emphasized that great interest is currently being shown in methods for evaluating knock ratings and for appraising their fundamental combustion phenomena. F. C. Burk discusses the test programs currently under way or contemplated to improve precision and significance of the engine test methods used for refinery control and specification purposes. An effort is being made to simplify these testing techniques as much as practicable.

The storage stability programs of the Office of the Chief of Ordnance and Bureau of Mines are reviewed by R. O. Bender, who points out that because of the chemical complexities of the problem, a combination of analytical and semi-functional tests may prove to be the most practical way of defining storage stability of gasolines.

The importance of engine cleanliness is heavily stressed by T. H. Risk and A. E. Cleveland. They emphasize the undesirability of any foreign substance, chemical or physical, which interferes with satisfactory operation of the engine. Included are sludge and varnish; combustion chamber, valve, and spark plug deposits; and adventitious dirt particles.

In his summary D. P. Barnard concludes: "As to the possible effects of fuel development on specifications: Changes in volatility specifications do not seem imminent. Refinements of knock testing procedures may require a new system of 'numbers' as the logical result of new calibrations. Specification of abnormal combustion properties (other than knock) seems a long way off, indeed. Changes in standardized stability specifications and provisions against chance dirt do not appear probable in the near future."

The contents are:

Introduction—Harold M. Smith, chairman of Committee D-2 on Petroleum Products and Lubricants, U. S. Bureau of Mines.

Gasoline Stability: Possible Effects of Current Research on Future Methods and Specifications—R. O. Bender, E. I. du Pont de Nemours and Co., Inc.

Motor Gasoline Octane Test Method Developments—F. C. Burk, The Atlantic Refining Co.

The Role of Motor Gasoline Additives—John M. Dempster, The Standard Oil Co. (Ohio).

The Effect of Composition on Future Motor Gasoline Specifications, or Vice Versa—W. J. Faust, Universal Oil Products Co.
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Other Abnormal Combustion Phenomena—

Are Gasoline Specifications Necessary?—D. L. Pastell and K. Hyatt, E. I. du Pont de Nemours and Co., Inc.
Present and Future Requirements of Motor Gasoline to Meet Needs for Satisfactory Engine Performance—T. H. Risk and A. E. Cleveland, Ford Motor Co.
Summary—D. P. Barnard, formerly with Standard Oil Co. (Indiana).

MATERIALS SCIENCES

Is a Complete Theoretical Metallurgy Near?

LLOYD BERKNER, president of the Institute of Radio Engineers, at the 13th Annual National Aerospace Electronics Conference in Dayton, Ohio, predicted revolutionary changes in materials technology in the next few years. He said that the result will be a complete theoretical metallurgy made possible by the use of computers. He also urged greater stress on graduate education, saying that the community which neglects this will become a colony of the one that does not.

Overcoming the Materials Barrier

IN SPACE exploration, in electronics, and in the harnessing of nuclear power, materials loom large as factors slowing progress. This problem is widely recognized, and at the ASTM Annual Meeting in June 1960, W. O. Baker, Bell Telephone Laboratories, in his address on the National Role of Materials Research and Development, told of plans for government support of interdisciplinary materials research laboratories at several universities. One of the universities selected to participate in this program was the University of Pennsylvania, whose president, Gaylord P. Harnwell, told the AIME at a session in Philadelphia last April what the university is doing about the problem.

Dr. Harnwell said, "... there is no question but that new types of problems are confronting those who are concerned with research and development in the science of materials and those who bear a responsibility for the education of the necessary scientists and engineers.

"Already technology has encountered a 'materials barrier.' In manned and unmanned flight, attainment of higher speeds and successful re-entry of the atmosphere call for materials that can stand up under unprecedented heat and stress. In power generation, the thrust developable by jet and gas turbines is limited not so much by mechanical consideration as by the ability of materials to withstand higher tempera-

tures. In electronics, the door has opened on an array of tiny new amplifying and switching devices—transistors, tunnel diodes, parametric instruments, thin magnetic film, and applications of low-temperature phenomena. These have started a race for materials having even more favorable properties of controlling the flow of electrons. In the harnessing of atomic power, a critical problem is the deterioration of materials used in reactors. Nuclear-powered aircraft await the development of a shielding material durable and light enough to encase a flying reactor, as well as materials to contain the reactor's temperature which will reach thousands of degrees. Throughout industry, the long battle continues against the easy fracture of metals at temperature extremes, the brittleness of heat-resistant ceramics, and the pure waste of corrosion.

"Materials research is of common interest to chemists, physicists, and metallurgists, and indeed they very often investigate the same phenomena from different points of view. Consider the study of magnetic materials. The chemist is concerned with their preparation and characterization; the metallurgist with the control of their micro and electron structures; and the physicist with the nature of magnetic interactions, particularly as related to crystal structure. There has been a growing recognition that these individual investigative efforts could be enhanced through a greater degree of collaboration; at the same time, it has become apparent that the education of the future participants in the emerging discipline of materials science should be based upon a more coordinated effort to relate the respective contributions of the three classical disciplines.

"In the United States, the Federal Council for Science and Technology several years ago decided that a concerted, intensified research effort by university scientists in many fields was called for. This was followed in 1959 by action on the part of the Advanced Research Projects Agency of the Defense Department whereby leading universities were invited to express interest in conducting a coordinated program of expansion of graduate research activities in the science and engineering of materials. Some 40 institutions did so, and the University of Pennsylvania was designated one of the first three schools for the establishment of programs. Perhaps a brief description of what will be known at Pennsylvania as the laboratory for Research on the Structure of Matter may be of interest to you.

"Currently, the broad areas which might be identified as materials science at the university involve 20 professors and about 90 graduate students. These include research activities in inorganic, structural, and theoretical chemistry; investigations in the School of Metallurgical Engineering in high-temperature thermodynamics and kinetics, the electronic properties of materials, and defects in materials; studies by members of the physics faculty in 'electronic' properties, theoretical solid-state physics, and low-temperature physics. The properties of semiconductors is of interest to members of the electrical engineering faculty, while several professors of chemical engineering are dealing with the behavior of materials subjected to specified gases at high temperature and pressure and with the treatment of mixtures of metallic and non-metallic oxides with the objective of separating the pure metal values.

"Interdisciplinary contact among these persons does indeed occur at present but is limited by the physical separation of the departments concerned and the resulting duplication of equipment and services. Moreover, most of the research is supported through contracts negotiated by individual professors either with industry or some government agency. The size and nature of these contracts and the interests of the supporting agencies generally inhibit interdepartmental cooperation. The new venture will essentially bring these presently scattered activities together under one roof where the newest devices and equipment will be available for use in a coordinated program of expansion in materials science. As envisaged, it will involve the doubling of present personnel, both professors and graduate students, after a steady state is reached some five or eight years hence.

"The plan calls for the erection by the university of a new structure of some 65,000 square feet, which will serve in addition to the 38,000 square feet presently devoted to materials science activities. In terms of architectural arrangement, every effort will be made to keep barriers to the movement and functioning of people at a minimum. This means that the central facility for a particular type of operation, such as X-ray diffraction, will be concentrated in a given physical area, and all those persons engaged in that activity (irrespective of their basic discipline or departmental affiliation) will be clustered around that central facility. Equipment will include one of the nation's few 100,000-gauss magnets, facilities for producing temperatures ranging from that of liquid helium to 5000 degrees Centigrade, apparatus for attaining almost absolute purity in semiconductors and metals, electron microscopes and diffraction equipment, and a variety of spectrometers, electron spin and nuclear magnetic devices, and X-ray diffraction equipment.

"It should be emphasized that the undertaking is one concerned with fundamental science as opposed to the solution of technical problems; the Federal government is thus projecting itself into a new and major avenue of support of basic research. The program is unique, too, in that the combined financial resources of

government and university will bring about three distinct benefits: new knowledge of the causes of materials failure, additional equipment and facilities and professional staff for the training of materials scientists, and additional numbers of students who will become teachers and researchers in the future.

"The benefits which will emerge from such programs will accrue to the future

conduct of basic research and development alike: a greater flow of basic knowledge applicable to the improvement and development of materials, the availability each year of additional scientists who will have gained maturity as staff members and research investigators, and the availability of increased numbers of young scientists who will have earned the doctorate in materials research. At the same

time, it is likely that the staff members of these programs will be available for consultation, and the equipment, when not otherwise committed, will be available for industrial research other than routine testing. In essence, this should prove to be a significant forward step in man's endless quest for better materials and can contribute to the eventual well-being of mankind."

DISTRICT ACTIVITIES

NORTHWEST

SUPPOSE THE tubing for your plant cost \$200 per ft; or suppose you had to make six million small balls to precise measurements from a rare-earth metal to protect your factory from earthquakes. Suppose you had to machine 3300 tons of graphite to exact dimensions, or perhaps buy several tons of steel plate clad with boron—a material never before mass-produced. Perhaps you would like to write a specification for high-density concrete using certain kinds of iron ore for aggregate . . . and then explain it to an iron ore producer. Maybe you would like to get rid of enough "waste" heat to warm the entire Columbia River perceptibly. Suppose every drop of your waste material—liquid, gas, or solid—had to be packaged better than the finest watch and then buried 75 ft under the ground; or suppose it took three men one hour just to change a light bulb in your shop. These are but a few of the everyday problems of the nuclear industry that were described to members of the ASTM Northwest District Council at their June 13 meeting in Richland, Wash.

At the Hanford Atomic Operations, situated on a 600-square-mile reservation, 8000 people labor to produce (1) plutonium—an artificial, radioactive, metallic element used as a basic ingredient for the atomic bomb—and (2) knowledge about the atom—what it is, what it does, and what can be done with it.

It was at this awesome operation that the Northwest District, in cooperation with the Columbia Basin sections of The American Society of Mechanical Engineers and the American Society for Metals sponsored a tour of the atomic facilities and a technical session on "The Material Problems in Large Nuclear Reactors." The featured speaker was John R. Carrell, manager, Process Design-Irradiation Processing Dept. During the tour, a test reactor was observed in operation, and several materials research laboratories in the chemical and ceramic fields were inspected.

Preceding the technical session a din-

ner was held in nearby Richland. A 50-year member award certificate was presented to Prof. S. H. Graf, formerly associated with the Department of Mechanical Engineering, Oregon State University, and now engaged in consulting work. Carl E. Minor, chairman of the Northwest District Council, presided at the ceremonies following the dinner.

In his slide-illustrated talk, Mr. Carrell detailed some of the materials problems faced in building a nuclear reactor. Aside from the materials of construction such as structural steel, high-density concrete, tubing, and electrical and thermal insulation, materials experts are called upon to evaluate materials for nuclear absorbers, reaction moderators, and fuel containers.

Much new information concerning the effects of neutron bombardment on materials has been developed. One

difficulty confronting the atomic scientists and engineers is their inability to impress materials producers with the importance of these findings. Many technical men do not yet appreciate the tremendous changes in the properties of materials that occur as a result of nuclear bombardment: Rubber insulation cracks, certain metals lose ductility, glass discolors, and even concrete undergoes chemical changes. The atomic engineer has other difficulties, too. Most often he cannot get near enough to the material to inspect it closely after it has been irradiated. A failure of any component in a radioactive area can take days, even months, to repair. Despite these handicaps, great progress is being made, and Mr. Carrell assured his audience that the materials problems can be and are being solved.

Arrangements for the meeting and tour were made by R. B. Socky, P. S. Kingsley, and Burt Kosut, all of the General Electric Co., Hanford Atomic Products Operation. Danny Marinos represented the ASME and Tom Evans represented ASM.

ACR NOTES ADMINISTRATIVE COMMITTEE ON RESEARCH

Creativity—A Valuable State of Mind

By WALTER J. SMITH¹

WHEN A RESEARCH OF development task is undertaken, definite provisions are usually made with respect to funds, facilities, period of performance, and a suitable selection of scientists, engineers, or both. The problems of supplying these requirements and establishing the program and its objectives are often the only concerns at the start of a project. Begun in optimism, the undertaking will ultimately reach its conclusion, with a greater or lesser degree of success. However, the return that is derived from a given size of effort can vary enormously. Moreover, it is often

¹Chemical Engineer, Arthur D. Little, Inc., Cambridge, Mass.

within the power of the research planner to exercise some control over the magnitude and extent of this return.

In the planning of research and development work, it is frequently overlooked that the outcome may very well depend more on certain personality traits of the technical team than on any other factor. The truly productive research worker is more than just a well-educated and trained scientist or engineer. Of course, he must be intelligent and possess the working tools and knowledge of his profession, but, in addition, he is set apart by a group of personality characteristics that make him creative and productive of new thoughts and ideas.

High intelligence and academic achievement do not alone guarantee that the individual will contribute outstandingly in original work. These attributes can, and often do, form the basis of a research career. Indeed, a great deal of useful and valuable investigative work that is recognized as high-grade research is being done by such individuals all the time, but often the genuinely creative touch is lacking. Characteristically, the approach in such a case is along well-established lines, and the new information is primarily a contribution to the existing fund. This is not to minimize the importance of such effort, but a project based solely on this type of research talent is likely to conclude simply as "a good job well done."

On the other hand, there are individuals who habitually come up with ingenious solutions to problems and with smashing new ideas. This results in the sharp advance and breakthrough that mark the most successful research ventures. Creativity is the name broadly and commonly applied to this useful but elusive quality. It exists in varying degrees. Some people develop creativity and resourcefulness readily and early in life, some more slowly, and others never at all.

The enormous value of the creative ability in research can hardly be overestimated. Personnel directors have tried to determine the nature of creativity and inventiveness so that these qualities might be discovered in a job applicant. Yet the only sure way to recognize the talent is to see it in action. Fortunately, the trait is a reliable one, and a creative person will perform as such again and again.

Many writers have tried to define and analyze the qualities that distinguish the creative researcher. The tendency has been to include: intense interest in the problem at hand, lively curiosity, eagerness, determination of purpose, and quick realization of the significance of an observation or piece of information. Nearly always, the creative person is close to his problem.

There is nothing especially remarkable about any of the foregoing qualities—all are quite common to humans everywhere. Yet, in proper proportion and setting, they can account for very great differences of accomplishment. There are some who regard creativity as a state of mind. This view is supported by the fact that the habit of creative thinking can be developed in an individual or group—and especially through close association with a person already so endowed. Research managers would do well to cultivate to the full this route to more productive working teams.

COMING MR&S PAPERS

- Size of Irregular Particles*—R. R. Irani and D. P. Ames, Monsanto Chemical Co.
The Determination of Organic Carbon on the Surface of Steel Sheets—W. E. Boggs and G. E. Pellissier, U. S. Steel Corp.
Exposure Fence Testing of Metal Protective Paints—C. A. Lominska, National Lead Co.
Determination of Chlorine in Gypsum and Gypsum Products—H. Surkevicius, Division of Building Research, Commonwealth Scientific and Industrial Research Organization, Australia.
Volume Changes in Concrete—M. A. Swayze, Lone Star Cement Co. (retired).
Quick and False Set in Portland Cement—W. C. Hansen, Consulting Chemist.
The Indirect Tension Test for Concrete—N. B. Mitchell, Cornell University.
Improved Adiabatic Calorimeter for Concrete—David Pirtz, University of California.

BOOKSHELF

Members who wish to be considered for reviewing books are invited to send in their names and subjects in which they are interested. Due to customs and mailing considerations, requests from the United States only can be considered. Copies of these books are not available through ASTM; all inquiries concerning them should be addressed to the publisher.

Handbook of Mechanical Wear

Edited by Charles Lipson and L. V. Colwell;
 The University of Michigan Press, Ann Arbor,
 Mich. (1961); 476 pp.; \$20.

Reviewed by J. W. Caum, ASTM Staff

EACH SUMMER the College of Engineering of The University of Michigan offers a number of selected, intensive courses treating engineering areas of either broad or specialized interests. The lectures presented in this volume comprise such a course on various aspects of wear, including causes and remedies.

Editor Lipson in his introduction has classified wear in the following commonly understood terms: (1) galling, scuffing, scoring, and seizing; (2) abrasion; (3) pitting; (4) fretting; (5) cavitation erosion; (6) galvanic corrosion. He explains further that, in practice, wear is usually a combination of one or more of these elementary forms, and it is difficult in most applications to state which types of wear have taken place. He is to be commended for his lucid approach to this complex problem.

The book contains 17 chapters as well as an introduction and summary by Editor Lipson. This collection of papers by distinguished authorities examines many of the different processes which result in wear and offers a wealth of material on such factors as material composition, environment, and history of the manufacturing operations. The University of Michigan should be congratulated on the choice of lecturers and should feel proud that such authorities participated in the lecture series.

The reviewer would recommend this handbook as a "must" for the library of all manufacturers of machines or machine components.

Directory of Continuing Numerical Data Projects

Office of Critical Tables, National Academy of Sciences—National Research Council, Washington, D. C. (1960); Publication No. 837; 66 pp.; paperback; \$1.

Reviewed by L. L. Wyman, National Bureau of Standards.

SINCE ITS organization in 1957, the Office of Critical Tables has had, as one of its functions, the identification of projects that operate on a continuing basis for the purpose of compiling and publishing numerical data.

In this effort, such projects have been classified into six categories consisting of (1) physicochemical, (2) crystallographic and mineralogical, (3) nuclear physics, (4) thermophysical, (5) spectrographic, and (6) comprehensive projects. Additionally, information has been obtained concerning the organization of the projects, substances, properties, data sources, and publication and distribution of the data. Also included is an item on "criticality," that is, an indication of the criteria and methods employed by project personnel to evaluate the data.

This directory represents the initial effort by the staff of the Office of Critical Tables to make available a compilation of over 40 project items which are classified under the six categories. As such, this booklet serves well to provide a short-cut to data sources for those who are active in the technical areas represented by the many projects presently included in the directory.

(Continued on page 586)

PROFESSIONAL CARDS

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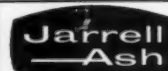
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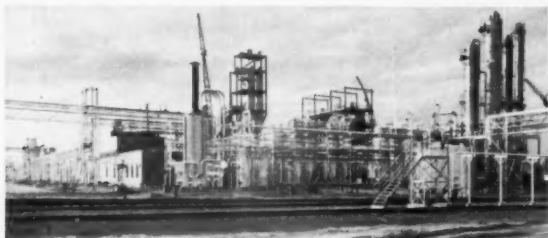
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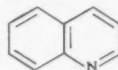
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glycerine, and nitrobenzene. The sulfuric acid dehydrates the glycerine to acrolein, the acrolein cyclizes against the benzene ring of the aniline, the sulfuric acid grabs off a third molecule of water, and the nitrobenzene oxidizes off two hydrogen atoms. The chain of events starts quietly enough but picks up considerable exothermic enthusiasm. Result: quinoline,



It was an exhilarating affair, particularly when we succeeded in pushing the yield close to 100%. Then we passed 100%, which was even more exhilarating. This we explained by assuming that the nitrobenzene was being reduced to more aniline for participation in the reaction. (Zdenko Hans Skraup would have been justifiably provoked with us for tortuous reasoning. His original proposal was merely to react nitrobenzene, glycerine, and sulfuric acid. Later, aniline was included.)

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A free procedural abstract and the quinoline come from Distillation Products Industries, Rochester 3, N. Y. (Division of Eastman Kodak Company). Same address can supply reagents and procedural abstracts to test many things for many ingredients. There is no charge for a list of the abstracts and none for the abstracts themselves, but there is a slight charge for the reagents.

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The common man came to equate speed with merit in photography. The wise men were sad. "No," they countered patiently, "the faster the emulsion the larger the grains must always be. There is no escape." But there was.

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Very recent advances in emulsion technology have produced the new Kodak Double-X Panchromatic Negative Film. For very short exposure times and 8 minutes in Kodak Developer D-19, it is just about as fast as Royal-X Pan Recording Film, but its graininess is much less—on a par with the fine grain and sharpness formerly attainable only in comparatively slow films.

The capsule-summary sheet "F3-297," available from Eastman Kodak Company, Photorecording Methods Division, Rochester 4, N. Y., tells about the physical forms of these and other Kodak films for instrumentation.

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This is another advertisement where Eastman Kodak Company probes at random for mutual interests and occasionally a little revenue from those whose work has something to do with science

BOOKSHELF

(Continued from page 581)

An Atlas of Process Defects—Plating Zinc Alloy Die Castings

BNF Development Report No. 64, The British Non-Ferrous Metals Research Assn., London (June, 1960), 30 pp., 15s.

Reviewed by E. A. Anderson, The New Jersey Zinc Co.

IN THE plating of metal objects a small percentage of the finished parts usually will be found to be defective for one reason or another. At times the incidence of a particular defect reaches alarming proportions and a change in practice is required.

The present report serves a useful function by showing photographically a variety of defects found in plated zinc alloy die castings with explanations of the causes and suggestions as to preventative measures. In all some 13 different defects are considered.

In general, the reviewer is in agreement with the explanations given. However, it is difficult to understand why the formation of blisters due to excessive alkaline cleaning has been omitted. These blisters take the appearance of those illustrated as case three and in the reviewer's experience are far more prevalent than those resulting from corrosion of the basis metal prior to plating.

Scientific & Technical Societies of United States & Canada

Seventh Edition, Publication 900, National Academy of Sciences—National Research Council, Washington, D. C. (1961); 467 pp. plus indexes; \$9.

Reviewed by F. F. Van Atta, ASTM Staff.

THIS BOOK presents information collected on 1836 societies during the summer and fall of 1960. The United States section (Part I) was compiled in the Library of the National Academy of Sciences—National Research Council in Washington, while the Canadian section (Part II) was compiled at the National Research Council in Ottawa. A separate index covers each part. Entries are limited to professional and selected amateur societies in the scientific and technical fields, according to the preface. Both national and local membership societies are included. Excluded are trade associations, county and small city engineering societies, local chapters of national societies, and voluntary health agencies whose sole purpose is the raising of money for research and therapy and whose primary activity is not scientific or technical.

This is a useful reference book for scientific librarians, editors, and others concerned with the names and addresses of scientific and technical societies.

Units of Weights and Measures (United States Customary and Metric) Definitions and Tables of Equivalents

National Bureau of Standards Miscellaneous Publication 233 (supersedes Miscellaneous Publication 214); Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C.; issued December 20, 1960; 20 pp.; 40 cents.

A 1959 AGREEMENT among the directors of National Standards Laboratories of English-speaking nations to obtain uniformity in precise measurements involving the yard and the pound have brought about refinements in the definition of the U. S. customary units of length and mass, and have made a revised edition of this publication desirable.

The units of length, area, volume, capacity, and mass in the United States are defined in conformity with the 1959 agreement, and the tables of interrelation and tables of equivalents for these units in the metric system and in the U. S. customary system have been recalculated by automatic computer.

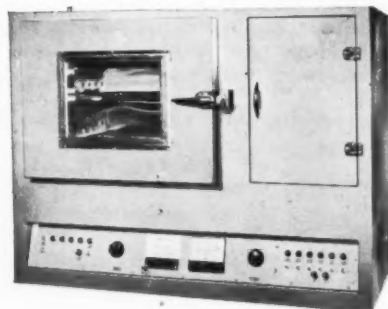
Further revisions include the deletion of the table showing interrelation between bushels and hectoliters and the addition of a more complete table showing equivalents of inches in millimeters.

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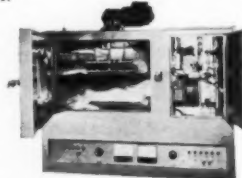
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Phoenix, Arizona

CALENDAR

July 27-Aug. 1—**International Symposium on Macromolecular Chemistry**, Queen Elizabeth Hotel, Montreal, Canada

July 30-Aug. 4—**American Crystallographic Association**, University of Colorado, Boulder, Colo.

Aug. 3-5—**The Chemical Institute of Canada**, Annual National Conference, Queen Elizabeth Hotel, Montreal, Canada

Aug. 13-18—**International Symposium on Micro-Chemical Techniques**, Conference Center, The Pennsylvania State University, University Park, Pa.

Aug. 14-17—**Society of Automotive Engineers**, National West Coast Meeting, Sheraton Hotel, Portland, Ore.

Aug. 23-26—**Electron Microscope Society of America**, 19th Annual Meeting, Pittsburgh Hilton Hotel, Pittsburgh, Pa.

Aug. 28-Sept. 1—**International Heat Transfer Conference**, University of Colorado, Boulder, Colo.

Aug. 30-Sept. 1—**American Institute of Mining, Metallurgical, and Petroleum Engineers**, Conference on Metallurgy of Semiconductor Material, Ambassador Hotel, Los Angeles, Calif.

Sept. 3-8—**American Chemical Society**, National Meeting, Chicago, Ill.

Sept. 14-15—**American Institute of Electrical Engineers and American Society of Mechanical Engineers**, Engineering Management Conference, Hotel Roosevelt, New York, N. Y.

Sept. 18-22—**Instrument Society of America**, Conference and Exhibit, New York, N. Y.

Sept. 19-21—**Technical Association of the Pulp and Paper Industry**, Fourth International Mechanical Pulping Conference, Edgewater Beach Hotel, Chicago, Ill.

Sept. 24-26—**Steel Founders' Society of America**, Fall Meeting, The Homestead, Hot Springs, Va.

Sept. 24-27—**American Public Works Association**, Public Works Congress and Equipment Show, Hotel Leamington and Auditorium, Minneapolis, Minn.

Sept. 24-27—**American Institute of Chemical Engineers**, National Meeting, Lake Placid Club, Lake Placid, N. Y.

Sept. 24-29—**Illuminating Engineering Society**, National Technical Conference, Chase Park Plaza Hotel, St. Louis, Mo.

Sept. 25-28—**American Welding Society**, National Fall Meeting, Hotel Adolphus, Dallas, Tex.

Sept. 25-28—**Association of Iron and Steel Engineers**, Convention, Penn-Sheraton Hotel, Pittsburgh, Pa.

Sept. 25-29—**Society of Automotive Engineers**, National Meeting, Curtis Hotel, Minneapolis, Minn.

Sept. 27-29—**American Association of Textile Chemists and Colorists**, Hotel Statler, Buffalo, N. Y.

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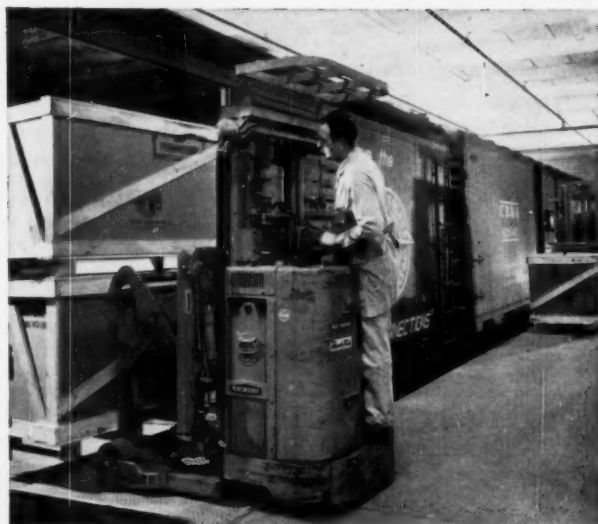
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MATERIALS AND TESTING TOPICS

This information is based on literature* and statements from apparatus manufacturers and laboratory supply houses. The Society is not responsible for statements advanced in this publication.

FOR THE LABORATORY

Display Oscilloscope—A bar-graph oscilloscope for continuous and simultaneous display of 48 input channels is announced. Called the ATL profile monitor Model 220, this instrument provides an accurate, easily interpreted, visual display of any phenomena measurable by an electrical output.

Advanced Technology Laboratories 3802

Transducer—A new transducer indicator is being offered. Used to measure accurately the output from bonded strain-gage type load cells, the Alenco Model TI-2 employs d-c excitation. This feature provides complete interchangeability of load cells and readout equipment and eliminates errors due to varying lengths in transmission and connecting cables.

Allegany Instrument Co.

3803

Electrical Thermometer—The Model T-1 precision electrical thermometer is a production, laboratory, maintenance, or field instrument that will instantly deter-

mine temperature of surfaces, liquids, or gases upon application of a thermistor sensing probe to the surface of substance to be tested.

Ameresco, Inc.

3804

Test Chamber—A small, high-temperature-low-temperature test chamber called "Econ-O-Line Mark II" has been introduced. It is designed to answer the requirements for temperature test capability both in the research and development laboratory.

Associated Testing Laboratories, Inc.

3805

Transducer Conditioner—A new universal input conditioning unit for data acquisition systems has the inherent flexibility for most typical applications. It is a single-channel module with an integral floating power supply. It may be used with 1-, 2-, or 4-arm bridges, and will adapt to any input wiring technique, including 8-wire bridge inputs. The shields are carried through the unit. The individual internal power supplies may be adjusted between 1 and 15 v dc.

B & F Instruments, Inc.

3806

Volumetric Solutions—Standard solutions for use in titration procedures are prepared directly from the 38 volumetric concentrates in the newly available Chemtam line. These include all commonly used materials as well as EDTA as a sodium salt. Concentrates are made available in special polyethylene ampoules which permit contamination-free and non-spill dilution directly in the neck of the volumetric flask.

BIO-RAD Laboratories

3807

Batch Ovens—Infinitely proportional, stable, straight-line control of temperature without cycling action is built into the power-O-matic 60 industrial batch ovens for the unusual length of temperature cycling tests in the electronics industry, plus aging, curing, drying, tempering; coil and armature baking, preheating plastics, core baking, and transformer tests.

Blue M Electric Co.

3808

Foam Tester—The Wohler foam tester is a low-cost yet highly accurate instrument for testing indentation compression of all flexible foams, including urethane, vinyl, and latex, in standard ASTM-RMA units. It will also perform several other tests required in foam development, research, and engineering.

Browning Instrument Co.

3809

Flame Photometer—Two new spectral filters have just been introduced for use with the Coleman flame photometer in laboratory determinations of magnesium

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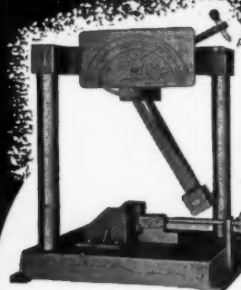
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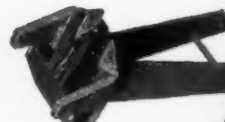


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and lithium. With its analytical scope now encompassing five important metallic elements, the flame photometer extends the advantages of flame analysis to academic, research, control, and soils laboratories.

Coleman Instruments, Inc.

3810

Transducer—A new pressure transducer designed specifically to meet the exceptional extra-rugged service and accuracy requirements of today's industrial and missile applications has been announced. Featuring an over-pressure capability of 10 times rated range, the Type 4-350 is virtually failureproof. Over-pressure performance is specified as 10 times the rated pressure or 10,000 psi (whichever is less) and when applied for 3 min will not cause a zero set to exceed 1.0 per cent of full-range output.

Consolidated Electrodynamics Corp.

3811

Laboratory Thermometer—A new externally calibrated laboratory thermometer for temperature measurements to an accuracy of ± 0.5 per cent of range has been announced. The new thermometer, Model 4200, can be used as a precision calibrated unit for laboratory measurements and as a check standard in calibrating other instrumentation such as mechanical recorders and controllers.

Daysstrom, Inc.

3812

Viscosity—A thermostated bath that can be operated up to 300 F and a working range that makes it easy to measure viscosities of well over a million centipoises are two of the new features of the improved MacMichael viscosimeter. The MacMichael is especially recommended for extremely viscous liquids and those whose viscosity cannot be determined in any other way: paints, varnishes, glue, resins, food products, lubricants, dairy products, gelatin, chocolate, heavy oils.

Fisher Scientific Co.

3813

Scales—Scales designed for laboratory or field weighing of aggregates samples are now being marketed. The scales combine features especially selected by Gilson to adapt them for use with the Gilson hydraulic and standard testing screens and the Gilson porta-screen (equipment for test sizing of concrete aggregates, coal, ores, minerals, and similar materials).

Gilson Screen Co.

3814

Grinding Machine—The Uni-Pol polisher-grinder is now available to research and development laboratories for fine lapping and polishing of semiconductor materials. The Uni-Pol is a versatile quality machine which incorporates an 80 to 1200 rpm variable speed control.

Geoscience Instruments Corp.

3815

Stiffness Tester—A factor table is now attached to the Gurley stiffness tester as standard equipment. This etched aluminum plate with convertible scale readings to milligrams of stiffness will eliminate the problem of the mislaid data card, formerly a problem in laboratories. The factor table, which can be attached to previously purchased

(Continued on page 592)

IMPORTANT NEWS

FOR YOUR

MATERIALS TESTING

The Marquardt TM-1 Auto-Dynamic Elevated Temperature Test Machine is now available for today's most exacting materials testing applications. The TM-1 is an automatic, servo-controlled system which measures and records modulus, yield, ultimate strength, and other physical properties of materials. Tests can be run under rapid heating and loading conditions to temperatures in excess of 5,000°F and with true strain control to 3/4 in./sec. Load and strain controls include linear, complex, or cyclic programs over a 50,000-pound range either in tension or compression. Marquardt's materials testing product line includes programmers, power controllers, extensometers, and related equipment.

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FOR FURTHER INFORMATION CIRCLE 1159 ON READER SERVICE CARD

FOR THE LABORATORY

(Continued from page 591)

instruments, is also being offered free of charge to each owner of a Gurley stiffness tester.

W. & L. E. Gurley

3816

D-C Null Voltmeter—Stability and resolution with 1 mv end-scale sensitivity, and a floating, high-impedance input are principal features of the new Model 413A d-c null voltmeter. The Model 413A has 13 zero-centered ranges, running from 1 mv to 1000 v end scale. High-input impedance (10 megohms on the most sensitive range, 200 megohms on the 300-mv range and above) makes this instrument especially valuable in resistance bridge measurements.

Hewlett Packard Co.

3817

Plastic Shields—Two new portable models have been added to the line of laboratory safety shields under the trademark "Lab-Guard." The manufacturer states that the portable shields are both of a compact weighted-base type, but differ in size and shape.

Instruments for Research & Industry

3818

Wire Tester—New equipment for the ultrasonic testing of wire permits the detection of inclusions as well as cracks running in any direction in one operation. Flaws and other discontinuities of the smallest size (as small as 10 per cent of diameter of fine wire), can be detected with great accuracy. The design of

this Lehfeldt equipment has overcome the problems of sound coupling between transducer and wire by using a liquid meniscus formed over an opening.

Marathon Specialty Steels, Inc.

3819

Test Machine—An auto-dynamic elevated-temperature test machine for testing advanced materials at extreme stresses, strains, and temperatures has been developed. Designed to meet exacting metallurgical testing requirements, the Marquardt TM-1 test machine is an integrated unit with the ability to simulate actual service conditions, that is, load and strain are controllable over a wide range; specimens can be heated slowly or in seconds; combined effects of rapid heating, rapid loading, constant loads, and cyclic loads can be determined. Accessory programmer provides capability of testing at varying conditions in a single test sequence, simulating the wide range of operating conditions encountered by aerospace systems.

The Marquardt Corp.

3820

Infrared Monitor—A new model in the Pyrotel line of noncontacting infrared radiation monitors and controls is designed to operate in the low-temperature range of 500 to 1200 F and higher. Designated the Pyrotel PY40, it has an optical system that can detect small or moving targets and will operate at distances of 12 in. to many feet away from the targets, with repeat accuracies of 0.5 per cent and response in milliseconds.

Mason Instrument Co., Inc.

3821

Test-Tube Racks—Available in a wide variety of sizes to handle laboratory glassware from micro test tubes to centrifuge bottles, the new stainless steel "Z-racks" meet all laboratory requirements. Formed of fine-finished stainless steel, in a one-piece shape that has no crevices or sharp corners, these racks offer maximum cleanliness and corrosion resistance. Absence of sharp edges assures maximum safety in handling.

Massey Dickinson Co., Inc.

3822

Strain Gage—The type P-8 is a new addition to the line of flat-grid polyester-base wire strain gages. The new gage has grid dimensions of $\frac{1}{16}$ by $\frac{1}{16}$ in. It may be installed at room temperature in 20 min using an adhesive. Operation is then possible to 400 F without elevated-temperature cure. The polyester base is transparent, which further assists in installation ease. Tests indicate excellent creep and hysteresis characteristics. Each gage is marked with gage factor, resistance, and lot number.

Metrix, Inc.

3823

Reduction Oven—The novel design of this oven prevents the undue loss of processed material. It provides maximum test reliability, enabling very precise chemical analysis. The electronically close-controlled high temperatures prevent unwanted chemical reactions. The unique design and durable construction enable the oven to operate continuously at elevated temperatures of 500 to 600 C.

Modern Laboratory Equipment Co., Inc.

3824

Semiconductor—A general-purpose semiconductor test set for measuring the important a-c and d-c parameters of transistors, diodes, and rectifiers can be used with all semiconductor devices, power as well as low-level silicon or germanium. Called the Model G-320, it offers pnp and npn polarity, is simply calibrated and easily operated, permits rapid device insertion, and employs long-life semiconductorized circuitry.

Molecular Electronics, Inc.

3825

Arc Melting Furnace—This furnace is designed for pilot alloy development of electronic materials used in semiconductor production, for example gold antimony, and for melting such difficult materials as gold, platinum, titanium, and other high-melting-point metals. The new furnace features water-cooled, nonconsumable tungsten arc tip to protect specimen purity; electrodes designed and balanced for improved arc stability; and all-around viewing through 360-deg glass band during entire operation.

MRC Manufacturing Corp.

3826

Drying Tube—A new calcium chloride Nalgene drying tube is designed with one bulb like the usual glass tube. This new design provides a tubulature at the bulb end and a tube fitting at the other end. Made of polypropylene, the tube is unbreakable and may be autoclaved.

The Nalgene Co., Inc.

3827

Liquid Scintillation—The first dual-channel liquid scintillation counting sys-

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FOR FURTHER INFORMATION CIRCLE 1160 ON READER SERVICE CARD

tem designed for room-temperature operation, called the Model 701, is designed for research applications requiring high sensitivity and efficiency in counting soft beta emitters such as carbon-14 or tritium. The newly developed instrument is intended for laboratories interested in manually counting limited numbers of samples.

Nuclear-Chicago Corp. 3828

Plasma Generator—A new 300-kw are plasma generator for materials testing and research in high-temperature chemical reactions and hyperthermal tunnel testing is said to operate at higher efficiencies than any other commercial are generator.

Plasmadyne Corp. 3829

Creep Test Oven—The Model 2300 creep-test oven is used for estimating the long-term strength of thermoplastic pipe when subjected to internal hydrostatic pressure. The test is applicable to all known types of thermoplastic pipe and for any practical temperatures. The experimental procedure is similar to that described in the ASTM Tentative Method of Test for Time-to-Failure of Plastic Pipe under Long-Term Hydrostatic Pressure (D 1598).

Research Appliance Co. 3830

pH Adapter—A new pH recording adapter for use with high-quality potentiometric recorders provides continuous and accurate recording of glass electrode pH for process study or titration, by measure or monitor.

E. H. Sargent & Co. 3831

Aging Oven—Recent studies in the ASTM rubber committee point to the fact that copper or copper-bearing material in apparatus used for pressure aging of rubber test specimens may cause serious contamination. The Scott Model LGP pressure aging oven eliminates this possibility, since it contains neither brass nor copper and features a pressure system with all components of stainless steel—test cylinders, valves, tubing, and manifold—to eliminate metal contamination of specimens under test.

Scott Testers, Inc. 3832

Sound Meter—A new exceptionally lightweight sound meter, Model 450, measures but 2 by 3 by 6 in., weighs only 2 lb, and is operated on an ordinary 22.5-v battery with an operating life of 30 hr.

H. H. Scott, Inc. 3833

Neutron Detector—Neutron detectors with applications for neutron flux monitoring, reactor flux and power mapping, oil well logging, neutron dosimetry, reactor safety devices, space exploration, and cosmic ray studies are now available. The unit, essentially a solid-state neutron-sensitive ionization chamber with millimicrosecond response and low gamma sensitivity, operates at 25 v, is available in two sizes (5 by 5 or 10 by 10 mm) and with uranium, boron, lithium, or hydrogenous material coatings.

Solid State Radiations, Inc. 3834

Concrete Penetrometer—The new pocketstyle concrete mortar penetrometer, Model CT-421, is used for fast evaluation of the "initial set" of concrete. To test, the penetrometer's $\frac{1}{2}$ sq in. shaft is forced into the concrete mortar 1 in. The resistance is shown on the direct-reading scale which holds its position until released. Scale range is from 0 to 700 psi.

Soiltest, Inc. 3835

Pressure Transducer—A new series of high-temperature gage and differential pressure transducers, the P732, that accurately measure pressures over a wide variety of ranges and under extreme environmental conditions have been introduced. The small and lightweight P732 pressure transducers of rugged stainless steel construction are temperature compensated for continuous operation to 600 F.

Statham Instruments, Inc. 3836

Curl Sizing Tester—The new Carson curl sizing tester for testing the degree of curl and sizing of papers up to 0.0010 in. in thickness features an improved timing system which permits the operator to make more precise measurements. It also features a totally enclosed liquid container that helps eliminate spills.

Thwing-Albert Instrument Co. 3837

Voltmeter—These high-impedance d-c TRVM's are completely self-contained instruments that require only $3\frac{1}{2}$ in. of

panel space and weight less than $1\frac{1}{2}$ lb. New circuit techniques reliably eliminate zero drift and the necessity for zero controls.

Trio Laboratories, Inc. 3838

Dosimeter Reader—New accessory equipment has been introduced to allow rapid conversion of any Turner fluorometer to the function of reading ionizing radiation dose and utilizing the new line of silver-activated glass dosimeter forms.

G. K. Turner Associates 3839

Ultrasonic Cleaner—The new Model SG-3 is designed for use with tanks up to 8-gal capacity. Although similar in design to the prototype Model SG-2, the new unit develops twice the power (400 w), enabling the cleaner to maintain the same cavitation strength despite the larger tank volume.

Will Corp. 3840

NEW LITERATURE

Pore Size—Accurate, simple, and quick measurements of the largest hole in a filter element can be made with the bubble point test stand described in *Bulletin A 11*. The test stand is used to detect damaged or otherwise imperfect elements prior to installation in an aircraft, missile, or ground system.

Aircraft Porous Media, Inc. 6447

(Continued on page 594)



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Standard Brinell testing machines. Direct reading, long stroke, and many other modifications available.

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FOR FURTHER INFORMATION CIRCLE 1161 ON READER SERVICE CARD

NEW LITERATURE

(Continued from page 593)

High-Voltage Testing—A complete engineering application analysis, titled "High-Voltage Testing: It Can Be Nondestructive," *Bulletin 5-15.4*, details the cause of insulation breakdown, the minimizing of destructiveness by current limiting, and many other pertinent aspects of insulation testing.

Associated Research, Inc.

6448

Strain-Gage Wiring—A line of neat, convenient strain-gage wiring terminals is described and illustrated in a bulletin recently published. The 4-page, 2-color *Bulletin No. 4340* includes photographs and drawings of the terminals, characteristics and specifications, features, types, dimensions, and curves of typical leakage resistance versus temperature for high-temperature terminals.

Baldwin-Lima-Hamilton Corp.

6449

Acralyzers—New *Bulletin K-4023* describing Beckman air-pollution acralyzers has been published. The acralyzers (automatic chemical reagent addition analyzers) are designed specifically to monitor and record low concentrations of oxidants, oxides of nitrogen, or sulfur dioxide in the atmosphere.

Beckman Scientific and Process Instruments Div.

6450

Ovens—New, 240-page multi-color *Catalog No. 161* illustrates and describes a

complete line of electric ovens, furnaces, baths, environmental cabinets, related temperature control equipment and accessories for laboratory, pilot plant, and production.

Blue M Electric Co.

6451

Heating Apparatus—The recently released *Burrell Catalog 92* describes a complete line of heating equipment and apparatus for the laboratory. This 24-page illustrated catalog offers a detailed description of Burrell manufactured furnaces including the high-temperature unit-package box and muffle furnaces and the Burrell high-temperature unit-package tube furnaces.

Burrell Corp.

6452

Air Pollution—Complete information about Cenco's air pollution field test apparatus, its purpose, construction, operation, and maintenance, is provided in a new 18-page illustrated *Brochure No. 313*.

Central Scientific Co.

6453

Instruments Catalog—The new 1961-1962 catalog is virtually a reference book for the chemist, engineer, biologist, and related user of scientific equipment. It contains a most comprehensive compilation of up-to-date instruments and equipment for general research, clinical study, production, quality control, and pilot-plant operation.

Cole-Parmer Instrument & Equipment Co.

6454

Shock Testers—Newly revised literature, *Bulletin 4-70*, describes the complete line of Hyge shock testers.

Consolidated Vacuum Corp.

6455

Engineering Manual—New *Bulletin R-2* illustrates the many uses of remote-indicating load-cell systems throughout industry and suggests imaginative ideas for new applications not already commonly known. It compares the new Dillon differential transformer principle with conventional tube and circuitry designs. It covers 33 capacities from 0 to 100 lb through 0 to 1,000,000 lb. Compression, tension, and push-pull models.

W. C. Dillon & Co., Inc.

6456

Catalog—A comprehensive 56-page, 2-color master *Catalog No. 614* provides complete information on an entire line of noise and field intensity meters, impulse generators, power density meters, modulation meters, coaxial attenuators, and a wide variety of microwave components.

Empire Devices, Inc.

6457

Accelerometer—"Fairchild Sub-Miniature Linear Accelerometers," a 4-page illustrated brochure, contains performance data on two models of sub-miniature linear accelerometers and a brief, concise summary of basic accelerometer principles.

Fairchild Controls Corp.

6458

Metallography—A "Guide to Metallographic Specimen Preparation" contains valuable information concerning current polishing methods.

Wm. J. Hacker & Co., Inc.

6459



FRL ENVIRONMENTAL TEST CHAMBER

Industrial and military demands in plastics, textiles, metals, etc., require tensile and compression testing far from the standard temperatures. To meet this need at a reasonable investment, the Model CS-90, FRL Environmental Test Chamber was designed specifically for use with either the floor or table model Instron Testers.



The Chamber is shown alone and in position with the Instron. The range of the standard Model is -90°F to $+750^{\circ}\text{F}$.

Catalog or Individual Brochure upon request.

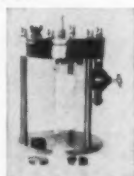
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Abrasion



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Flammability

FOR FURTHER INFORMATION CIRCLE 1162 ON READER SERVICE CARD

Test Equipment—New 48-page *Catalog No. 21-B* describes testing equipment for cement, concrete, solids, bituminous, and petroleum products.

Humboldt Mfg. Co. 6460

Bantam-Ware Catalog—A new 32-page Bantam-ware *Catalog BW-2* has over 150 new items in the expanding line of small organic glass apparatus. Three new kits are featured.

Kontes Glass Co. 6461

Chemical Catalog—The 1961 A.R. catalog contains a complete listing of more than 400 reagents in addition to descriptive data on other laboratory chemicals and solvents. Also included in the book is complete information on ordering, labeling, and packaging.

Mallinckrodt Chemical Works 6462

Chemical Safety—Revised editions of four chemical safety data sheets are now available. These booklets on benzene, *SD-2*; nitric acid, *SD-5*; paraformaldehyde, *SD-6*; and anhydrous ammonia, *SD-8*, list not only the characteristics of these chemicals, but also the hazards, engineering control of hazards, employee safety procedures, fire-fighting techniques, recommended handling and storage practices, tank and equipment cleaning and repair procedures, waste disposal, medical measures necessary, and first-aid requirements.

Manufacturing Chemists' Assn., Inc. 6463

Chemical Catalog—A new catalog, listing an expanded line of laboratory chemicals, contains over 5000 laboratory listings, including organics, inorganic reagents and elements, and a comprehensive line of stains and indicators.

Matheson Coleman & Bell 6464

Ceramic Diode—Technical *Bulletin No. M-103*, a 2-page data sheet describing the new ceramic diode closure, lists complete specifications on the new ceramic diode closure which meets MIL specifications and is rated for use at -65 to 150°C .

Metalizing Industries, Inc. 6465

Radioactivity Instruments—A new 96-page catalog, describing more than 250 instruments, counting systems, radio-nuclides, and nuclear accessories has been announced. Forty-eight per cent of the new catalog is devoted to descriptions of new products introduced since the previous catalog two years ago.

Nuclear-Chicago Corp. 6466

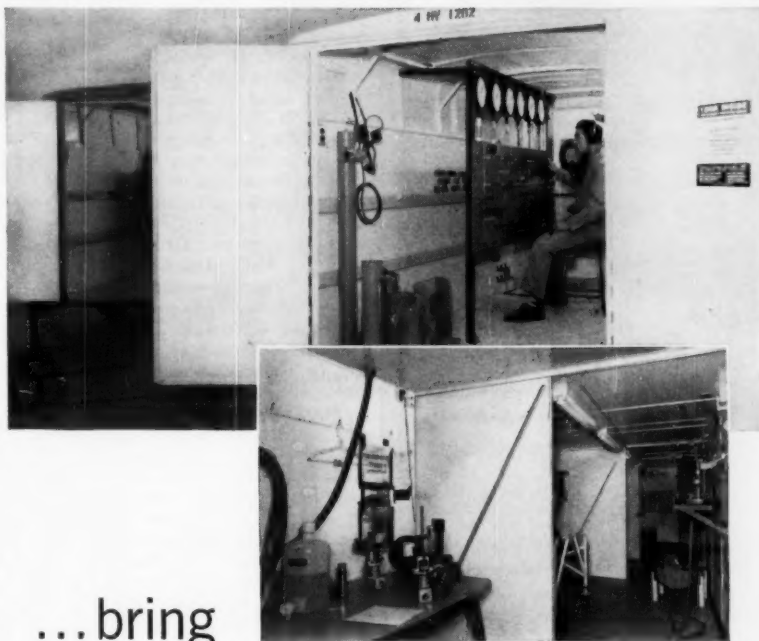
Potential Tester—A new 8-page catalog of high-voltage test sets and power supplies lists 10 pieces of new equipment recently released, including a special cable hipot tester, insulating oil dielectric tester, and multiple output dielectric test set.

Peschel Electronics, Inc. 6467

Isotope Chambers—A new 6-page folder, providing engineering data on 19 isotope chambers for gamma radiography is available. Specifications are given for eight chambers that employ iridium-192 and for eleven chambers that use cobalt-60. Text discusses radiog-

(Continued on page 596)

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NEW LITERATURE

(Continued from page 595)

raphy procedures, features, operation, and equipment construction.

Philips Electronic Instruments 6468

Gas Chromatograph—How to obtain speedy, reliable solutions to routine gas and volatile liquid analysis problems with a chromatograph is explained in a new 2-color, 4-page bulletin on the Chronofrac, Model VP-1. *Bulletin No. 619* carefully demonstrates stability and resolution of this instrument through the use of several actual chromatograms.

Precision Scientific Co. 6469

Voltage-Current Calibrator—*Technical Bulletin 60-C* describes Model 1082 precision voltage-current calibrator, a highly sensitive comparator-type signal-measuring instrument that samples and measures a-c pulse, or d-c signals from 1 mv to 10 v, and accepts input signal bandwidths to more than 100 Mc.

Rese Engineering, Inc. 6470

Catalog—New 16-page Lab-ORATORY, with over 50 timely and new analytical laboratory items for the chemist, features thermostats, constant-temperature equipment, circulators, fraction collectors, recorders, fluorophotometers, evaporators, chromatography items, heating jackets and tapes, stirrers, water-bath shakers, and reflection gloss meters.

Schaar and Co. 6471

Compressibility—New *Brochure A* reports a few of the wide range of developments in internal investigation of compressibility, vehicle suspension, high-performance devices using intensified electrical energy, cable impact, and magnetic liquid spring development. Also described and illustrated is the Tayco designed and manufactured linear accelerator for high-velocity testing in a wind tunnel.

Tayco Developments, Inc. 6472

Thermocouples—A new, 10-page *Catalog 2550* describes the processes used to produce TEMPAC thermocouple material.

Temptron, Inc. 6473

Paperboard Tester—Now available is a data sheet illustrating and describing the ply bond tester. This testing machine was created to meet the need for additional physical testing of laminated products, gummed tape, and other packaging materials requiring high strength.

Testing Machines, Inc. 6474

Catalog—A 12-page technical brochure, "Moisture-Density Determinations For Civil Engineering Works," describes in detail an improved nuclear system for taking rapid field measurements of soil moisture content and soil density. The system consists of a radioactive source, a detector for the source, and a scaler to indicate the amount of radiation detected.

TESTlab Corp. 6475

Apparatus Catalog—More than 20,000

carefully evaluated items are listed in the 61st anniversary edition of the catalog, "Scientific Apparatus and Reagents," now being distributed to scientists. Format of the encyclopedic, 1148-page volume has been revised to render it lighter in weight for easier handling, but extensive listings of the latest laboratory instruments with full complement of accessories have been retained.

Arthur H. Thomas Co. 6476

Titration—Two-page data sheet outlines continuous, automatic method for determination of total acidity. The method details a means by which, with the addition of a suitable buffer, slight changes in acid concentration will give only slight changes in indicator color, instead of the usual sharp, complete change.

Technicon Controls, Inc. 6477

LABORATORIES

The Bendix Corp., Ann Arbor, Mich.—A new space chamber for the dress rehearsal of large satellites prior to launch into orbit has been announced. The new vacuum test chamber, 20 ft in diameter and 27 ft long, is being constructed as part of a major expansion of the Corporate Space Laboratory at the Bendix Systems Div., Ann Arbor, Michigan. When completed in October of this year, the expansion will provide a \$10 million facility for the development, assembly, and test of complete spacecraft.

Owens-Illinois Glass Co., Toledo, Ohio—A new research and testing laboratory dedicated to the improvement of paper products from tree to corrugated and solid fiber shipping boxes and multiwall bags has been opened in Toledo, Ohio, by the Forest Products Group of Owens-Illinois Glass Co. The new facility, located adjacent to O-I's Technical Center, ranks as one of the best equipped in the paper industry.

Quantum, Inc., Wallingford, Conn.—This leading commercial research laboratory has established a nuclear research division and opened a regional office at Buffalo, N. Y. The research division, which is located at the Western New York Nuclear Research Center on the campus of the University of Buffalo, will be the primary site of Quantum's research in radioactive tracer techniques, radiation effects, radiation chemistry, activation analysis, and other nuclear science technologies.

MATERIALS

Indium Clad Aluminum—The new tri-clad alloy junction material, indium clad aluminum, is now fully described in a technical data bulletin. *Bulletin Z-107* describes the sequential melting process which makes the indium clad aluminum preform highly desirable in forming p-

(Continued on page 598)

Materials Research & Standards

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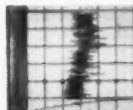
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MATERIALS

(Continued from page 596)

type alloy junctions in germanium semiconductors.

Accurate Specialties Co., Inc., Hackensack, N. J.

Glass Fiber—A new 8-page brochure discussing diverse applications of glass fibers and the manufacturing methods of producing them has been published. In addition to discussing characteristics and capabilities of filament winding and centrifugal molding, the booklet, titled "Focus on Fibre-glass," describes the advantages of matched-metal molding and premix molding for specific types of products.

Apex Reinforced Fibre-Glass Div., Cleveland, Ohio

Chemical—A 12-page bulletin describing properties, uses, and handling of the versatile chemical trimethoxyboroxine (TMB) has been issued. The booklet covers in detail the principal applications of TMB as a metals fire extinguisher; as a primary curing agent for epoxy resins; and as an agent for nitrogen removal from refinery feed stocks. Case histories are given on experimental fire extinguishing for zirconium sponge, magnesium chips, titanium sponge, and magnesium castings. Typical physical properties listed include vapor pressure at varying temperatures, solubility of organic liquids

in TMB at 25 C, and solubility in organic compounds in TMB.

Callery Chemical Co., Callery, Pa.

Alloy—"Properties of the New Cobalt-Base Alloy UMC0 50" are reported in a recent publication of the Cobalt Information Center. This latest research report on the alloy (50 per cent Co, 30 Cr, 20 Fe) contains data on its structure, its room-temperature tensile strength, and 100-hr stress-rupture strength at 1600 and 1800 F, and the effect of additions (interstitials and substitution elements—Mo, Si, Nb, and Ti). Data on the basic alloy (low carbon) show that it can be cast and forged without difficulty and that it has adequate room-temperature properties (good tensile strength and sufficient ductility); high-temperature tensile and stress properties that compare favorably with the complex superalloys above 1650 F; excellent wear and abrasion resistance, particularly at high temperature; good thermal shock resistance; satisfactory machinability; good oxidation resistance in air and air-sulfur dioxide mixtures; and good corrosion resistance in sulfuric and boiling nitric acid and molten zinc.

Cobalt Information Center, Battelle Memorial Inst., Columbus, Ohio

Industrial Felt—A catalog features a "Ready Reference Index" which alphabetically lists hundreds of applications of industrial felts with the proper type to use. There are tables listed under roll felts and sheet felts with the following pertinent

TESTshaker

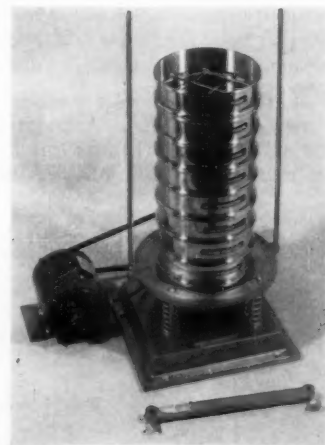
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FOR FURTHER INFORMATION CIRCLE 1168 ON READER SERVICE CARD

Materials Research & Standards

data: Federal Specifications CF-206A, Commercial Standards 185-52, SAE Specifications, comparative price coefficients, general properties, physical properties, mechanical properties, chemical properties, and fabricating methods.

Continental Felt Co., New York, N. Y.

Copper-Lithium Alloys—Articles on the copper-lithium system are described in a new annotated bibliography. The abstracts cover all the published literature on this subject and are arranged in chronological order. An index provides handy reference to such subjects as physical and chemical properties, uses, analysis, preparation, and the standard phase diagram.

Foote Mineral Co., Philadelphia, Pa.

Tungsten Alloy—Kennertium is a new trade name for the heavy tungsten alloy. Principal improvements are in ductility and tensile and compressive strengths. Elongation has been increased to the range of 10 to 25 per cent (½-in. gage length). Its ultimate tensile strength ranges up to 135,000 psi and its compressive strength to 500,000 psi. A reduction in length of 52 per cent without cracking was produced under a load of 500,000 psi. Yield point in compression is 85,000 psi. Hardness is 270 to 297 Brinell, and the modulus of elasticity is 45,000,000 psi. Kennertium has a coefficient of thermal expansion of 3.7×10^{-6} per deg Fahr in the range of 100 to 1200 F. Electrical conductivity is 15.5 per cent of that of copper, and it is virtually nonmagnetic. Other properties of Kennertium are given in a new 8-page bulletin.

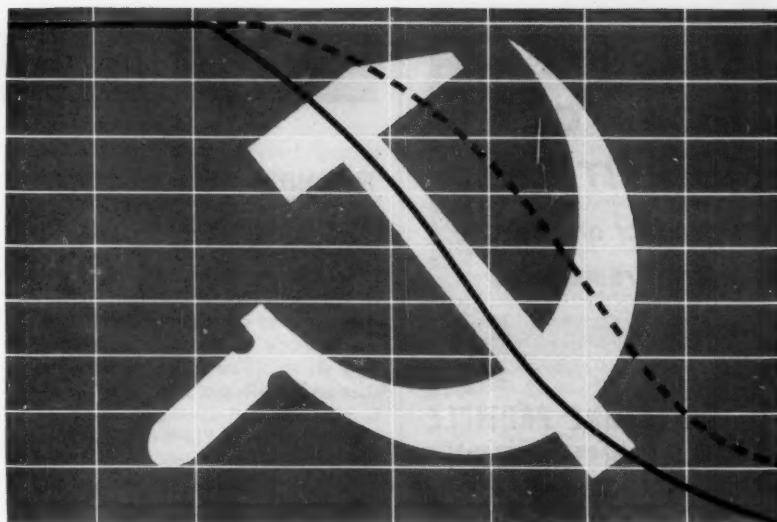
Kennametal, Inc., Latrobe, Pa.

Steel—A steel industry "first"—the commercial production of rolled structural shapes made from quenched and tempered alloy steels—has been announced. Heat treated to design strengths as much as three times that of structural carbon steel, the new shapes are said to promise "important weight and cost savings in a host of structural applications ranging from submarines to skyscrapers." Furnished in standard I-beams, channels, and angles, and in lengths up to 40 ft, the new shapes are produced from several well-known quenched and tempered alloy compositions. These include: USS "T-1" and "T-1" type A constructional alloy steels; 9 per cent nickel steel for cryogenic applications at temperatures as low as -320 F; and HY-80 naval armor steel.

U. S. Steel Corp., Pittsburgh, Pa.

"... It is clear that we are the victims of an epidemic of repetitious research reports; that these reports have more often than not been commissioned to substitute for action rather than to accomplish it; and finally, that the original reports, the good ones, are almost never acted upon or are acted upon only after the trouble they have pointed to has engulfed us."

"The Longest Way from Thought to Action", Edward T. Chase, *The Reporter*, June 22, 1961.



HOW MUCH DO YOU REALLY KNOW ABOUT SOVIET TECHNOLOGY?

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Automation and Remote Control

Avtomatika i Telemekhanika — Articles on all phases of automatic control theories and techniques. Published monthly by the Academy of Sciences, U.S.S.R. ('57, '58, '59 and '60 issues available)

Instruments and Experimental Techniques

(Pribory i Tekhnika Eksperimenta)—Bi-monthly published by the Academy of Sciences, U.S.S.R. Articles relate to function, construction, application and operation of instruments in various fields of experimentation. ('58, '59 and '60 issues available)

Measurement Techniques

(Izmeritel'naya Tekhnika)—Published monthly by Academy of Sciences, U.S.S.R. Particularly interesting to those engaged in study and application of fundamental measurement. ('58, '59 and '60 issues available)

Industrial Laboratory

(Zavodskaya Laboratoriya)—Published monthly by the State Scientific-Technical Committee of the Council of Ministers, U.S.S.R. Presents articles on instrumentation for analytical chemistry and physical and mechanical methods of material research and testing. ('58, '59 and '60 issues available)



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RANDOM SAMPLES

R_x: Plastics

PLASTICS are being found increasingly useful in surgery and other medical applications. There are many good reasons for using certain plastics—they are inert and therefore do not react in the body to produce toxic effects; they are stable for long periods of time; they are lightweight; and they are easy to mold into intricate shapes.

Many different kinds of plastics help in the treatment of eyes and ears. Implants of silicone rubber have been used to reinforce and support corrected detached retinas; this technique has already prevented blindness in more than 2000 cases. Methyl methacrylate is a standard material for contact lenses. Artificial plastic eyeballs are available, and artificial corneas are now being developed. Plastics can be used to patch perforated ear drums in such a way that infections do not set in to complicate healing; polyethylene tubing has been implanted in the middle ear to restore continuity of sound pressure.

There has been moderate progress in adapting plastic glues for medical purposes. Polyurethane foams have been used as adhesives, and applied directly to fractures and broken bones, but there are complications. An ideal material would permit the patient to move his glued limb within hours and use it two to seven days after setting. Then, eventually, new bone would grow through and around the plastic and finally replace it. So far, the idea has not worked out very well in practice, but development is continuing. Glue is now used to seal surgical incisions without leaving scars, and where surgery cannot compensate for extensive surface damage, lifelike plastic parts can be made up and attached with plastic glue.

Plastics are sometimes used for equipment which takes over the actual life-sustaining processes of the body. One recently developed machine circulates and oxygenates blood while surgeons operate on immobilized hearts and lungs. Thin films of silicone rubber, used in the diffusion of blood, help to make such machinery practical. Other silicone compounds have actually been injected into the circulatory system to retard coagulation and break air bubbles in the blood as they pass through the machine.

Plastics have a variety of other uses as replacements within the body. Plastic heart valves have been implanted in over 4000 people, and plastic arteries have become well-established surgical aids. In some instances, the cervical

esophagus (that part in the neck) can be reconstructed completely in the form of nylon tubing, and polyethylene tubes can replace other parts of the esophagus that have been ruptured by cancer. A surgical mesh of woven plastic filaments can be used to mend or reinforce areas that will not mend naturally—the woven mesh is open enough to permit bodily tissue to penetrate the mesh easily during the healing process.

In the operating room itself, plastics are unusually useful aids. For example, clear vinyl film can be substituted for surgical towels. The body is sprayed with an adhesive and then the sterilized film is fitted on; the surgeon makes the incision directly through the film, and after the operation is over, he either peels off the film and glues or sutures the wound or he can sew up the incision right through the film. This technique is particularly useful in brain surgery, because the anesthetist is free to observe the patient's face throughout the operation; normally, it would be swathed in towels. Silicone-coated nylon sutures are used in neurosurgery to prevent adhesion to nerves and tissues, and woven plastic compounds coated with a silicone compound may be applied to keep dressings from sticking to severe burns.

Several innovations have added to the comfort of patients. Plastic vaccinators may even be used; vaccine-treated prongs on plastic strips to the same job more effectively than the long needle, and there is less pain and scarring. For the bed-ridden, silicone oils are sprayed on the skin, to prevent bedsores and infections. And the beneficial effects of aspirin may be prolonged by mixing it with polyvinyl acetate.

Industrial Bulletin
Arthur D. Little, Inc.
February, 1961

Stiffness Changes in Superconductive Metals

THE FIRST complete measurements of the mechanical stiffness of metals cooled until they have lost all resistance to electrical currents—measurements that will help provide a better understanding of what makes memory elements in computers behave the way they do—have been made at the Ford Motor Co.'s Scientific Laboratory.

It has been known for some time that certain metals when cooled to temperatures near absolute zero lose their elec-

Materials Research & Standards

trical resistance completely. This phenomenon—superconductivity—has never been explained satisfactorily by theory, but two important applications of the phenomenon are the cryotron, the memory element for computers, and, more recently, a new type of extremely powerful magnet.

For several years, physicists have predicted that when a metal cools to the critical temperature at which it completely loses its electrical resistance, there would be a change in the elastic stiffness of the metal during the transition. The Ford measurements confirm that there is such a change, varying from 0.5 to 200 ppm for the cubic metals studied—lead, vanadium, tantalum, and columbium.

The new measurements represent the first time a complete examination of this effect has been carried out. Because of the completeness of the data, it was possible to show that what the theory of superconductivity has neglected as a source of energy to change a metal into a perfect conductor may, in fact, be the main source of such energy. These measurements not only permit the energy calculation, but they also make it possible to bring together several other experimental pieces of information which have been collected over the past few years in many laboratories around the world.

As is often the case with a new experimental technique, several completely unexpected effects were discovered. It was found, for example, that decreasing the temperature stiffened all the metals much more gradually than expected. Also discovered were odd variations of the stiffness with temperature in tantalum and columbium, which were associated with minute amounts of impurities. The variations appeared when the samples were sheared in one way and were absent during different shearing distortions.

U-2's Help Support Rain Theory

AMERICAN U-2 AIRCRAFT have gathered evidence which strongly supports an Australian theory of how rain is formed. The U-2's collected high-altitude dust samples in an effort to help determine their source.

It is already known that clouds are likely to form rain when the atmosphere is full of tiny, solid particles. These particles, which fill the earth's atmosphere from time to time, become the nuclei for ice crystals that melt and become rain, the Australian scientists say.

One unanswered question involved here is the origin of the particles. They may be thrown up from the earth, but E. G. Bowen, chief of the Division of

Radiophysics in the Commonwealth Scientific and Industrial Research Organization, believes they may originate from meteor showers that enter the earth's atmosphere from outer space.

If dust from the ground is the source of the particles, their number should rapidly decrease with altitude. Few should be found above 30,000 to 35,000 ft, Dr. Bowen says. On the other hand, if the particles are coming from outer space, there should be just as many at great heights as there are lower down.

To find out which idea was correct, the high-flying U-2's were fitted with special dust-collecting filters designed by Keith Bigg of the CSIRO radiophysics laboratory. Flying over Sale, in southern Australia, the U-2's picked up dust samples that showed considerable numbers of particles up to 60,000 ft and higher. This has led the scientists to believe that the particles are coming from outer space.

The Australians hope to get more data by taking measurements up to 100,000 ft, probably with balloons. They will also try to identify the particles chemically. The information they gather, CSIRO believes, will be of vital importance in understanding the weather and in forecasting rain.

Chemical and Engineering News,
Dec. 12, 1960

a message about CAWO x-ray paper

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LETTERS

¶ Congratulations on your editorial in the March issue on the relative importance of space research. I enjoyed it very much. The choice you mention should be made as clear as possible, but it is frequently swept under the rug. Such editorials as this one do a great service.

W. L. DOLCH
Research Associate,
School of Civil Engineering,
Purdue University, Lafayette, Ind.

¶ Since approving the galley proof for my article ["Some Thoughts on the Information Problem"] in the June issue, I have accepted employment with Jonker Business Machines as Director of Information Services. If it is not too late to do so, could you so indicate in the article?

I appreciate that it may be too late, but if you can make the change, I will appreciate it.

JOHN C. COSTELLO
Director of Information Services
Jonker Business Machines, Inc.
Gaithersburg, Md.

[It was too late.—Ed.]

¶ We have read with interest the excellent article in the January issue of *Materials Research & Standards* by Mr. Roscoe Bloss, on the evaluation of resistance strain gages. Since this subject is one of continually increasing importance to our industry, we feel we should direct your attention to an error of reference in one of the discussions following the paper.

In the comments of Mr. Peter Stein (p. 15), mention was made of "NASA Standard 942." The reference here, actually, is to National Aerospace Standard 942. The National Aerospace Standards (usually abbreviated NAS), are published by this Association and are developed by various of the AIA technical committees. NAS 942 was prepared by specialists from a number of aerospace manufacturers participating on Project 14-58 of the Aerospace Research and Testing Committee. Purposes of the specification are to: (a) establish a standard nomenclature for bonded resistance strain gages; (b) prescribe the minimum amount and kind of qualification test data to be furnished by strain gage manufacturers; (c) define the minimum capabilities of the test equipment to be used to obtain the qualification test data; and (d) set forth the methods to be used to obtain the qualification test data. This ambitious specification now has seen wide reference use both in our industry and by manufacturers of elevated temperature strain gages.

We suggest you bring this correction to the attention of your readers, both to avoid embarrassment to NASA and to assure that inquiries regarding NAS 942 are properly channeled. Copies of the standard are available either through this office or directly from our publisher, National Standards Assn., 616 Washington Loan & Trust Building, Washington 4, D. C.

As noted above, we believe that Mr. Bloss's article is an important contribution to the contemporary technology surrounding evaluation of high temperature strain gages. Accordingly, we should like to bring this particular article to the attention of our industry specialists who were involved in the development of NAS 942 and who, in general, represent our Association in this field. Are reprints available? If so, can you advise the means whereby we might obtain approximately 60 copies for distribution to our member companies? I would appreciate your advice on this matter.

H. D. MORAN
Technical Service, Aerospace Industries Assn.,
Los Angeles, Calif.

[The error was ours, not Mr. Stein's. The reprints have been sent.—Ed.]

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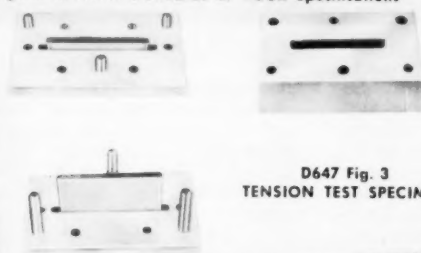
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CIRCLE 1176 ON READER SERVICE CARD

THE AMERICAN Ceramic Society announced at its meeting in April new officers, fellows, and awardees, among whom were the following ASTM members: **J. H. Koenig**, director, School of Ceramics, Rutgers University, New Brunswick, N. J., president-elect; **Leonard G. Ghering**, president, Preston Laboratories, Inc., Butler, Pa., vice-president; **Elroy E. Howe**, vice-president and director of research, Chicago Vitreous Corp., Cicero, Ill., vice-president; **Benjamin J. Sweo**, technical director of research, Ferro Corp., Cleveland, Ohio, trustee. **Arno M. Illing**, manager of research and development, Cambridge Tile Manufacturing Co., Cincinnati, Ohio, and **Van E. Campbell**, Ohio Brass Co., Barberton, Ohio, have been designated as fellows. **Hobart M. Kraner**, head, Ceramics Research Dept., Bethlehem Steel Co., Bethlehem, Pa., received the John Jeppson Award for "his distinguished and unselfish service to technical, professional, and educational ceramic groups, and his outstanding technical contributions to the electrical porcelain, refractories, and metallurgical industries."

The Metal Powder Industries Federation elected new officers, several of whom are ASTM members. **W. Arthur Irvine**, manager of production engineering, The Maytag Co., Newton, Iowa, was elected president, and **Kempton H. Roll** was re-elected executive secretary and treasurer. The trade associations comprising the federation also elected officers, and among these are several ASTM members. **Earl Lowe**, president, Greenback Industries, Inc., Greenback, Tenn., was elected president, Metal Powder Products Assn.; **Peter V. Schneider**, head, Powder Metallurgy Dept., International Business Machines Corp., Endicott, N. Y., was re-elected president of the In-Plant Powder Metallurgy Assn.; and **Norbert K. Koebel**, director of research, Lindberg Engineering Co., Chicago, Ill., was re-elected president of the Powder Metallurgy Equipment Assn.

Richard C. Alden, now retired, formerly director of research and later chairman, Research Planning Board, Phillips Petroleum Co., received from the American Petroleum Inst. its Certificate of Appreciation for long and valued oil industry service. His citation read as follows: "A constant toiler, a self driver, a wise and consistent advocate of the promotion of scientific knowledge, he has given generously of his time and efforts to the affairs of the Division of Refining. His early work on the composition of gasoline is recognized as classic. . . . His warm personality and his dedication to the application of science for the good of America have won for him a place in the hearts of all refiners and contributed to his worthiness of this Award." Residing in Sarasota, Fla., Mr. Alden is a former ASTM National Director, was for many years

vice-chairman of ASTM Committee D-2 on Petroleum Products and Lubricants, and was chairman of the Society's Long-Range Planning Committee. Also receiving an API Certificate was **W. J. Sweeney**, vice-president, Esso Research and Engineering Co. Mr. Sweeney has rendered long service to the petroleum field as one of the nation's leading research executives.

O. A. Battista, chemist, American Viscose Corp., Marcus Hook, Pa., has been receiving wide publicity for his discovery of a method for breaking down cellulose to make it edible. Palatable cellulose foods, which have little or no food value, should prove to be a potent weapon in the battle of the bulge. Dr. Battista is a member of Committee D-23 on Cellulose and Cellulose Derivatives.

Johan Bjorksten, president, Bjorksten Research Foundation, Madison, Wis., is the new president of the American Institute of Chemists.

Wallace R. Brode, formerly associate director, National Bureau of Standards, Washington, D. C., has been named an Honorary Member of Sigma Pi Sigma, National Physics Honor Society. He is president of the Optical Society of America and was recognized for his contributions to the field of optics and spectroscopy and his editorship of the *Journal of the Optical Society of America* for the past eleven years.

N. F. Chamberlain has been promoted to research specialist, Humble Oil & Refining Co., Baytown, Tex.

ASTM president-elect **Miles N. Clair** has just completed a three-year term as president of the Salvation Army Greater Boston Assn. Dr. Clair received a gavel commemorating his three years as president at a dinner in Boston with more than 500 in attendance. Among his other responsibilities down through the years in the Salvation Army, Dr. Clair has had the direction of raising substantial sums required for the Boston Association's budget.

Alvin G. Cook has been appointed coordinator, product specifications, Allegheny Ludlum Steel Corp.'s Brackenridge, Pa., research center. He was previously assistant to chief corporation metallurgist, specifications.

D. K. Crampton, for many years director of research, Chase Brass and Copper Co., Waterbury, Conn., has recently retired after 44 years of service with the company. However, he is continuing as consultant for Chase and is devoting about two days a week to various activities. A former National Director of the Society (1950-1953), Dr. Crampton in 1956 delivered the Gillett Memorial Lecture on "Structural Chemistry and Metallurgy of Copper." He has been very active in the work of many ASTM technical commit-

tees, including B-5 on Copper and Copper Alloys, of which he served as secretary for eight years.

Clarence A. Dauber has been appointed head, Thermal Power Engineering, Chas. T. Main, Inc., Boston, Mass. Formerly Mr. Dauber was director, civil and mechanical engineering, The Cleveland Electric Illuminating Co., Cleveland, Ohio.

Theodore P. Dresser, Jr., is now president and chief engineer, Abbot A. Hanks, Inc., San Francisco, Calif. Formerly he was vice-president and chief engineer. Mr. Dresser was made an Honorary Member of the Society at the 64th Annual Meeting last month (see page 565).

Norman G. Gaylord is now president, Gaylord Associates, Inc., Newark, N. J. Previously he was vice-president, research and development, The Western Petrochemical Corp., Newark, N. J.

Gary G. Guthrie, formerly quality control engineer, ITT Kellogg, Orcutt, Calif., is serving in the same capacity with General Dynamics Corp., Rapid City, S. Dak.

John B. Haertlein has been appointed chief metallurgist, Metals Disintegrating Co., Division of American-Marietta Co., Elizabeth, N. J.

F. R. Hensel, vice-president, engineering, P. R. Mallory & Co., Indianapolis, Ind., retired June 1, 1961. Dr. Hensel has been an individual member of the Society since 1940 and also represented his company in ASTM membership.

Thomas L. Kablach, formerly technical director, Roll Manufacturers Inst., Pittsburgh, Pa., is now plant metallurgist, Titusville Div., Struthers Wells Corp., Titusville, Pa.

C. S. Kimball is now president, Foster D. Snell, Inc., New York, N. Y. Formerly he was executive vice-president.

Koppers Company, Inc., Verona, Pa., recently announced changes in personnel in the Product Development Dept., Tar Products Div. **Charles U. Pittman**, formerly technical director of industrial pitches, has assumed the duties of the recently established position of market development director, bulk products, and **Merle D. Chamberlain**, technical director of building materials, has been assigned the technical direction of industrial pitches, in addition to his present duties, and has been named to the new post of technical director, bulk products.

Peter Korol, formerly laboratory chemist, Naget Cove Barium Corp., Ltd., Calgary, Alta, Canada, is sales representative, Ontario District, Hagan Corp. (Canada), Ltd., Weston, Ont., Canada.

Harold C. Malloy, previously engineer, Texaco Inc., Houston, Tex., is general sales manager, Union Asphalts and Road Oils, Inc., Kansas City, Mo.

Orrin W. McMullan, director of research and development, Bower Roller Bearing Div., Federal-Mogul-Bower Bearings, Inc., Detroit, Mich., has been named research consultant.

Robert T. O'Connor has been named acting chief, Cotton Physical Properties Laboratory, U. S. Dept. of Agriculture, Southern Utilization Research and Development Div., New Orleans, La.

Harry C. Plummer, director of engineering and technology, Structural Clay Products Inst., Washington, D. C., was made a fellow of the Construction Specifications Inst. The citation recognized his "distinguished and dedicated service" to the organization and noted that his "selfless contribution of time, wise counsel and immeasurable effort have been reflected in the orderly development of the CSI as a

well recognized national technical organization."

R. L. Reading, Belden Manufacturing Co., Chicago, Ill., retired recently. Mr. Reading represented his company on Committee B-1 on Wires for Electrical Conductors and was a consulting member of Committee D-9 on Electrical Insulating Materials.

A. M. Reeder retired May 1, 1961 from the Jones & Laughlin Steel Corp., Pittsburgh, Pa. Mr. Reeder was his company's representative on Committees B-1

(Continued on page 606)

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NEWS OF MEMBERS

(Continued from page 605)

on Wires for Electric Conductors, A-5 on Corrosion of Iron and Steel, and A-1 on Steel.

F. N. Rutherford is general manager, Pencomex, S. A., San Angel, Mexico. He had been manager, Technical Dept., Commercial Descalzi, S. A., Mexico, D. F., Mexico.

Erle I. Shobert II, manager of research, Stackpole Carbon Co., St. Marys, Pa., has been elected a member of the Board of Directors, Susquehanna University, Selinsgrove, Pa.

E. C. Shuman is now supervisor, Building Industry Research Program, Engineering Experiment Dept., The Pennsylvania State University, University Park, Pa. He had been manager of engineering, Engineering and Industrial Services, Sales Div., Owens-Corning Fiberglas Corp., New York, N. Y.

Thomas E. Stelson, acting head, Department of Civil Engineering, Carnegie Institute of Technology, Pittsburgh, Pa., has been appointed ALCOA Professor of Engineering.

C. R. Stock, formerly supervisor, Analytical Section, American Cyanamid Co., Santa Rosa Plant, Fla., is now

manager, Fibers Application Laboratory, Bound Brook, N. J.

Clarence J. Tobin, researcher, consultant, and metallurgical processing expert, retired June 1, 1961, from General Motors Research Laboratories, Warren, Mich. Mr. Tobin was a long-time member of Committees B-2 on Non-ferrous Metals and Alloys and E-4 on Metallography.

J. A. Vaughan, director of research, Southern Wood Preserving Co., Atlanta, Ga., retired July 5, 1961. Mr. Vaughan represented his company in Society membership and also on Committee D-7 on Wood since 1945.

David M. Wilson is now senior engineering assistant, Peninsula Testing and Controls, Mountain View, Calif.

Norman H. Withey, formerly materials engineer, Madison, Wis., is now concrete engineer, Lock Joint Pipe Co., Wharton, N. J.

ASTM Past-President **Kenneth B. Woods**, head, School of Civil Engineering, Purdue University, has received the title "Distinguished Alumnus" from the College of Engineering, Ohio State University. Professor Woods received his civil engineering degree from Ohio State. In his citation, reference is made to his significant work in ASTM. His citation mentions his leadership and support of engineering education, his outstanding engineering accomplishments, and his administrative and executive abilities.

DEATHS

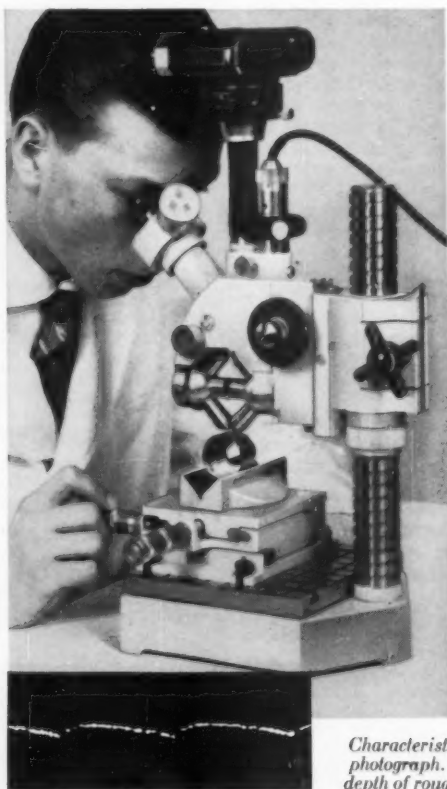
R. A. Balderson, president, Precision Thermometer and Instrument Co., Philadelphia, Pa. (May 13, 1961). Mr. Balderson represented his company in Society membership, and was on Special Advisory Subcommittee 17 of Committee E-1 on Methods of Testing.

Jose Manuel Bisbe, 155 E. 76th St., Apt. 7E, New York, N. Y. (recently). Mr. Bisbe joined ASTM as an associate member in 1957.

James B. Braden, assistant manager of sales development, United Carbon Co., Inc., Akron, Ohio (April 27, 1961). Mr. Braden was an individual member of the Society and represented his company on Committees D-24 on Carbon Black and D-20 on Plastics.

Francis G. Church, technical supervisor, Union Carbide Consumer Products Co., Division of Union Carbide Corp., New York, N. Y. (May 9, 1961). Mr. Church had been a member of the Society since 1954 and of Committee D-15 on Engine Antifreezes since 1955. He was vice-chairman of the main committee and chairman of Subcommittee II.

Almon H. Fuller, professor emeritus of civil engineering, Iowa State College,



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Ames, Iowa (March 31, 1961). Professor Fuller's membership in the Society dates back to 1903.

Richard F. Graef, vice-president and chief engineer, Knoerle, Graef, Bender and Associates, Inc., Baltimore, Md. (February 6, 1961). Mr. Graef had been a member of the Society since 1956.

James B. Hartman, professor and head, Department of Mechanical Engineering, Lehigh University, Bethlehem, Pa. (May 7, 1961). Dr. Hartman joined ASTM in 1957.

Ruth Ann Jago, president, Thwing-Albert Instrument Co., Philadelphia, Pa. (May 28, 1961). Associated with the company for 43 years, and an officer since 1938, Miss Jago became president in 1957. She attended many ASTM meetings and was a strong supporter of the Society. She was active in the Scientific Apparatus Makers Assn. and the Technical Association of the Pulp & Paper Industry.

John M. Lessells, president, Lessells and Associates, Inc., Boston, Mass. (May 17, 1961). Mr. Lessells joined ASTM in 1924 and has been active in committee work, most recently in Committee E-9 on Fatigue.

C. E. Paul, St. Petersburg, Fla., professor emeritus of mechanics, Illinois Institute of Technology, Chicago, Ill. (May 2, 1961). Professor Paul was a member of the Society for 53 years and a member of Committee D-7 on Wood for 43 years.

OTS REPORTS

These reports, recently made available to the public, can be obtained from the Office of Technical Services, U. S. Department of Commerce, Washington 25, D. C. Order by number.

Characteristics Governing the Friction and Wear Behavior of Refractory Materials for High-Temperature Seals and Bearings, *PB 171 010*, \$1.50.

Research and Development on the Effects of High Pressure and Temperature on Various Elements and Binary Alloys, *PB 171 348*, \$2.

Effects of Temperature-Time-Stress Histories on the Mechanical Properties of Aircraft Structural Materials, *PB 171 328*, \$2.50.

Fatigue and Stress Rupture Properties of Inconel 713C, V-57C and Titanium Alloys 7Al-3Mo-Ti and MST 821 (8Al-2Cb-1Ta-Ti), *PB171 064*, \$2.25.

Protective Coatings for Refractory Metals, *PB 171 193*, \$1.50.

Ozone Resistance of Elastomeric Vulcanizates at Elevated Temperatures, *PB 161 969*, 50 cents.

Measurement of the Thermal Properties of Metals at Elevated Temperatures, *PB 171 185*, 75 cents.

Heat Fused Ceramic Coatings for Aluminum Components of Rocket Launchers, *PB 171 047*, 50 cents.

Internal and Surface Temperatures of

Rubber Exposed to Direct Sunlight, *PB 171 042*, 50 cents.

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Polymerization of Styrene and Butadiene by Gamma Radiation, *PB 171 041*, 50 cents.

The Effects of Alloying Elements in Titanium, *PB 151 094*, \$3.50.

Availability and Mechanical Properties of High-Strength Steel Extrusions, *PB 151 097*, \$1.75.

Production and Availability of Some High-Purity Metals, *PB 161 226*, 50 cents.

Welding of Columbium and Columbium Alloys, *PB 161 219*, 50 cents.

An Investigation of Intermetallic Compounds for Very High Temperature Applications, *PB 171 081*, \$3.

Determination of the Mechanical Properties of Aircraft-Structural Materials at Very High Temperatures after Rapid Heating, *PB 161 893*, \$2.25.

Development of Low Alloy Steel Compositions Suitable for High Strength Steel Castings, *PB 171 065*, \$2.

Evaluation and Alloy Development of Hot-Work Die Steels for Structural Purposes, *PB 171 008*, \$2.25.

The Mechanism of Hardening in 17-7PH Stainless Steel, *PB 161 850*, \$1.50.

Minimum Toughness Requirements for High-Strength Sheet Steel, *PB 161 786*, 75 cents.

Toughness of Steel Sheet: The Advantage of Laminating, *PB 171 044*, 75 cents.

Ultrasonic Methods for Near-Surface Flaw Detection, *PB 161 048*, 50 cents.

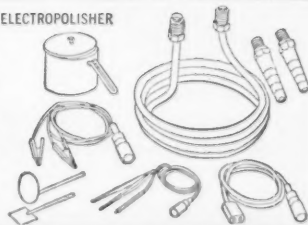
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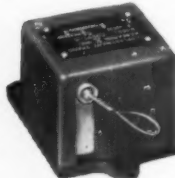
R-I Potentiometric Displacement Transducers provide a wide range of deflection measuring capability. Designed for measuring displacement during aircraft structural loading tests, they may also be used in other static and dynamic applications.

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Model 4046 has a maximum range of $3/4"$, accuracy is $\pm 1\%$ of range. Cable tension: 8-12 oz. Response rate: up to 50 ft./sec.² Weight only 9.5 oz. Size: $1\frac{1}{4}" \times 1\frac{1}{4}" \times 1\frac{1}{4}"$.

Model 7100 has detachable cable which separates from reel when fully extended. Range: 12 inches. Cable tension: 16 oz. Max. operating temp: 222°F. Size: $3\frac{1}{2}" \times 2\frac{1}{2}" \times 2"$.



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NEW MEMBERS

The following 100 members were elected from May 8, 1961 to June 7, 1961 making the total membership 10,560... Welcome to ASTM. Names are arranged alphabetically, company members first then individuals. Your ASTM Year Book shows the areas covered by the respective Districts.

Central New York District

Flanagan, B. L., Jr., district manager, Pittsburgh Testing Laboratory, Pittsburgh, Pa.

Central Plains District

Plum, Russell V., technical director, Keokuk Steel Casting Co., Keokuk, Iowa.

Chicago District

Einsweiler, Frank L., co-owner, V & E Construction Co., Galena, Ill.

Hart, Robert G., construction engineer, Siesel Construction Co., Milwaukee, Wis.

Pantell, James W., plant metallurgist, Screw and Bolt Corporation of America, Gary, Ind.

Ricketts, Charles J., project engineer, Sundstrand Aviation, Division of Sundstrand Corp., Rockford, Ill. [A]*

Thornburn, Thomas H., professor of civil engineering, University of Illinois, Urbana, Ill.

Walker, J. H., chief administrative officer, Research and Development Laboratories, Portland Cement Assn., Skokie, Ill.

Walter, Virlyn W., manager, Corporate Standards Dept., Motorola, Inc., Franklin Park, Ill.

Cleveland District

G. S. Equipment Co., The, Thomas R. Gill, president, Cleveland, Ohio

Detroit District

Chieger, Daniel, director of engineering, Automotive Div., Young Spring and Wire Corp., Detroit, Mich.

Davis, Sanford, research supervisor, Wyandotte Chemicals Corp., Wyandotte, Mich.

Hampton, James E., technical director, American Aggregates Corp., Detroit, Mich.

Nagel, D. W., assistant production manager, Fenestra, Inc., Detroit, Mich.

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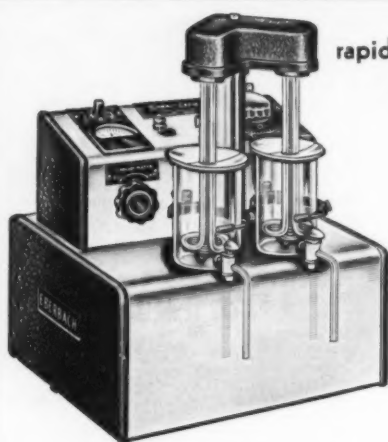
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The following items appeared in Supplement 2 for April, 1961.

INITIATIONS

Title	Type of Action	Symbol or Number	FSC Class	Assigned Agency & Preparing Activity
Antiseize Compound, Whitehead Base General-Purpose (for Threaded Fittings).....	Am. 1	TT-A-580a	8030	GSA-FSS
Bags and Envelopes, Cellophane, Packaging.....	New	PPP-B-15	8105	Army-QMC
Boxes, Wood, Cleated-Plywood.....	Am. 1	PPP-B-601	8115	Army-QMC
Boxes, Wood, Household Goods.....	New	PPP-B-580	8115	Army-CE
Boxes, Wood, Wirebound.....	Rev.	PPP-B-585	8115	Army-QMC
Cloth, Cotton, Muslin, Mercerized.....	Rev.	CCC-C-422a	8305	Army-QMC
Copper-Base Alloy Cast Bar.....	New	QQ-C		Army-Ord
Copper, Ingots.....	Rev.	QQ-C-00521c	9850	Navy-Ships
Dyeing and Aftertreating Processes for Cotton Fabrics.....	Rev.	CCC-D-950a	8305	Army-QMC
Insulation Block, Pipe-Covering, and Cement, Thermal Calcium Silicate (for Temperatures up to 1200 F)....	Am. 2	HH-I-523a	5640	GSA-FSS
Insulation Tape, Electrical, Pressure-Sensitive, Adhesive.....	New	HH-I-00595	5970	Navy-WEP
Paint, Ready-Mixed, Outside Medium Chrome Yellow.....	Am. 1	TT-P-53c	8010	Army-CE
Pipe, Copper, Seamless Standard.....	Rev.	WW-P-377b	4710	Navy-Ships
Roofing, Felt, Roll, Asphalt-Prepared, Mineral-Surfaced.....	New	SS-R-630	5650	Navy-Docks
Sealer, Hot-Poured Type, for Joints in Concrete.....	Int. Am. 2	SS-S-184	8030	GSA-FSS
Soap, Laundry, Chip, and Powdered... and Low Tites.....	New	P-S-579	7930	Army-QMC
Soap, Laundry, Powdered High Tites and Low Tites.....	New	P-S-585	7930	Army-QMC
Soap, Tillet (Floating White and Cake Milled).....	New	P-S-620	8520	Army-QMC



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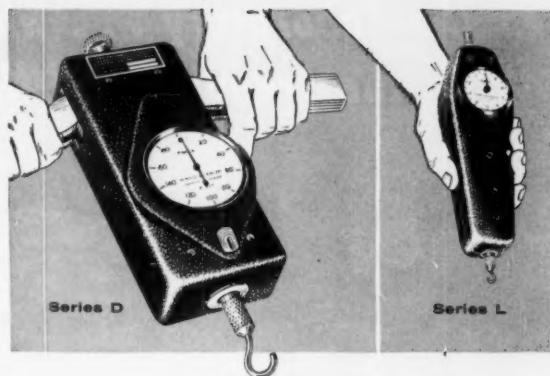
Title	Type of Action	Symbol or Number
Brass, Leaded.....	Rev.	QQ-B-613b
Brass, Leaded and Nonleaded: Rod, Shapes, Forgings, and Flat Products with Finished Edges (Bar, Flat Wire, and Strip).....	Rev.	QQ-B-626b
Box, Wood, Cleated, Veneer, Paper Overlaid.....	New	PPP-B-576
Psychrometers.....	New	GG-P-725
Roofing, Felt, Roll, Asphalt-Prepared.....	New	SS-B-630
Wire, Fabric, Steel, Welded, (for Reinforced Concrete)	New	RR-W-375
Wire Steel, Corrosion-Resisting.....	Rev.	QQ-W-423a

SPECIFICATIONS AND STANDARDS APPROVED FOR PRINTING

Soap and Soap Products (Including Synthetic Detergents), Sampling and Testing.....	Chg. Not. 2	Fed. Test Method Std. No. 336
Aluminum-Alloy Forgings, Heat-Treated.....	Am. 1	QQ-A-367e
Bolt, Square-Neck; Bolt, Machine; Bolt, Ribbed-Head; Bolt, Finned-Neck; Bolt, Tee-Head; and Bolt, Key-Head.....	Rev.	FF-B-584b
Boxes, Fiberboard, Corrugated, Triple, Wall.....	Rev.	PPP-B-640b
Cardboard and Railroad Board (Manila and Wood).....	Am. 1	UU-C-201c
Cloth, Cotton, Denim, Shrunken and Unshrunken.....	New	CCC-C-421
Cloth, Cotton, Duck, Bleached.....	Rev.	CCC-C-442a

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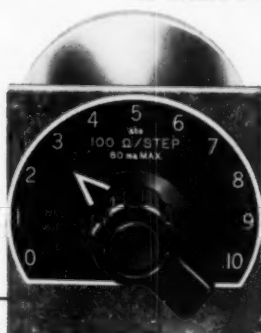


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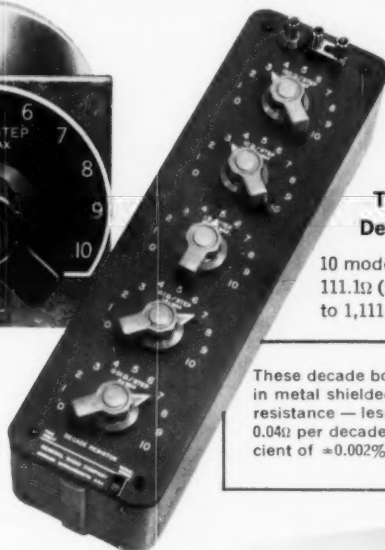
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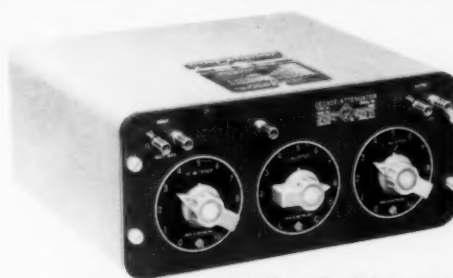
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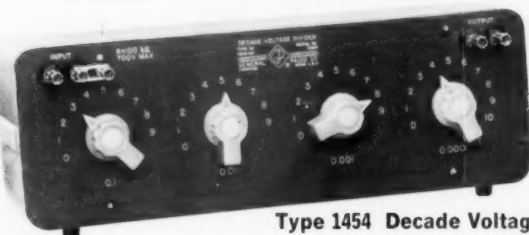
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